HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge,
Honolulu, Hawaii.

Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1919.

IMPERIAL BUREAU
31 MAY 1930
OF MYCOLOGY

Issued September 10, 1920.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, July 29, 1919.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1919.

Respectfully,

J. M. WESTGATE,
Agronomist in Charge.

Dr. A. C. TRUE,
Director States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
E. T. MEREDITH,
Secretary of Agriculture.

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[1] Appointed Apr. 9, 1919, to succeed M. O. Johnson, resigned.
[2] Temporary appointment, Apr. 1 to June 30, 1919.

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1919.

SUMMARY OF INVESTIGATIONS.

By J. M. WESTGATE, *Agronomist in Charge.*

INTRODUCTION.

During the past year the energies of the station were largely directed to the most pressing problems of production of food for human beings and feeds for animals. This work in part was successfully carried out by the distribution of seeds, cuttings, and plants to individuals and to public institutions. Improved varieties were given wide distribution, up-to-date cultural methods, including spraying for insects and fungus enemies, and other means used to increase crop yields, were received and adopted to a gratifying degree by the producers. Pleasant cooperative relationship was maintained with the Territorial food commission, and especially with its corps of county agents.

The station continued to emphasize the desirability of increasing the production of diversified crops. It is and has long been fully realized that locally grown diversified crops must compete, to a large extent, with crops imported from the coast. These are often imported at less expense for freight than is paid on similar crops from the other islands of the group. In Hawaii the uneven surface of the land usually devoted to diversified crops and the small size of fields necessarily increase the amount of hand labor required, thereby increasing the cost of production. It is felt, therefore, that too great stress can not be laid on the desirability of having many new kinds of crops produced in considerable quantities so that the agricultural practices necessary to the production of these crops on a large scale could be readily adopted in case any calamity should befall the sugar, pineapple, or banana industries.

Tendencies in the island seem to have been the nonencouragement, rather than the encouragement, of production of diversified food crops. This fact is borne out by the recent failure of the Territorial legislature to make an appropriation for the continuation of the agricultural county-agent system, and likewise by their withdrawal of the customary appropriation from the Territorial marketing

division. The latter, during the past seven years, developed from a small beginning to where, in April, May, and June of 1919, it handled $56,249.72 worth of produce and filled a long-felt need for the consumer and small producer. At the time that the county agents were eliminated, provision was made for a sugar-cane expert, at a salary of $500 a month, to advise and assist those raising sugar cane on their homesteads. The Territorial financial support was also withdrawn from the Glenwood substation, it being proposed to transfer the agricultural experimental work of the Territory to the opposite side of the island of Hawaii, where there are larger areas of potential homesteading land suitable for the production of diversified crops. An appropriation was made for the establishment and maintenance of a new station at Waimea, Hawaii; unfortunately, however, the money appropriated was to be supplied from the "loan fund," which, it is claimed, can be used for permanent improvements only and not for the operation of an experiment station. At its last session the legislature authorized the expenditure of $5,000 for farm buildings at the Haleakala demonstration farm. It is planned to construct these buildings in 1920, loan funds having been provided for that purpose.

Although the Territorial legislature saw fit to withhold its support from the Territorial county-agent system, it is universally acknowledged throughout the islands that this method, as developed during the war period, thoroughly demonstrated its efficiency in bringing home to the mixed population of the islands those improvements in agricultural practices deemed desirable for general adoption. The personal contact of the county agent with the tiller of the soil is the most effective means of solving the many difficult problems confronted by the producing classes. It is hoped that subsequent Territorial legislatures will reestablish the Territorial county-agent system to supplement the Federal extension work at present under way.

COOPERATIVE ACTIVITIES.

It has been the policy of the station to undertake work in cooperation with individuals, institutions, and organizations, both public and private, wherever the work in question promised to be of mutual advantage. It was felt that by giving careful attention to the formulation and execution of plans, many projects could be as effectively carried out through the cooperation of such an agency as though the station unaided had undertaken the entire work. Such cooperation would make it possible to provide for many more projects than can be cared for when the entire cost of the work is borne by the station alone.

As specific instances, it should be noted that the station continued to cooperate with representatives of the several military posts

throughout the islands, and provided seeds and plants for gardens of the various companies. These gardens, which proved a very valuable adjunct to the needs of the local military establishments, were looked after by specially detailed men from each company, the work usually being assigned to those who showed a decided liking for it. Prizes won at the last two Territorial fairs indicate, in some measure, the success achieved in vegetable raising by the gardeners. The products from each company's garden formed a most welcome addition to the standard Army rations, and, in some instances, the attempts to farm proved so successful that the supply of products obtained exceeded their demand.

The station established an increasing number of cooperative relations with small farmers, and with a number of the larger ranches and plantations. The small grower was provided with such seed and planting material as was found practicable, and all possible information and assistance necessary to further any particular line of his work was furnished him. With larger concerns, the station usually confined its efforts to giving expert advice and assistance in outlining those experiments carried out by the men in charge of the ranch or plantation. Since these experiments sometimes extend over a number of years, those having their immediate oversight must carefully follow them up until the results of a number of seasons have been obtained. It was found, owing to the great diversity in rainfall, altitude, and soil conditions, that experimental results true of one locality may not be true of another, even though separated by only a few miles. For this reason it was desirable to repeat, in the immediate localities where work was to be tried out on a larger scale, those experiments which were successfully carried on by the experiment station. These repetition trials are ordinarily conducted in cooperation with private parties, it not being felt that continual close supervision on the part of the station is as essential as is the case with the regular station experiments.

In addition to the above-mentioned cooperation, the station maintained relations with agricultural societies, chambers of commerce, business men's clubs, and with the trustees of several large estates who are broadly interested in the development of diversified agriculture. The Hawaiian Sugar Planters' Experiment Station, and some of the pineapple, sugar, and banana plantations proved very helpful in a number of cooperative undertakings.

Informal cooperative relations also existed between this and various State experiment stations, and with the several branches of the United States Department of Agriculture at Washington, as well as with the agricultural departments of many foreign countries.

NEED OF SUPPLEMENTARY FOOD CROP INDUSTRIES.

The Hawaiian Islands depend entirely too much upon the sugar industry for their true prosperity, and there is always the possibility that the market price of sugar may fall to such a level that many of the plantations would be forced out of business. There is further a strategic need for the growing of other crops, so that these islands may be less dependent on the outside world for their food. It was, therefore, considered as especially desirable that the development of diversified industry be either in the actual production of food crops or, at least, in the production of agricultural products from which foods can be prepared. In normal times these crops would be available for export either in the raw or manufactured state, and, during a time of blockade or interruption of communication, they could be readily used to feed the local population.

With this end in view, various root and tuber crops were grown for their starch production, and the process of drying and preserving vegetables and fruits received careful attention from many of the station workers. F. G. Krauss, superintendent of the extension division, in company with a representative of one of the local agricultural companies, made a trip of inspection and investigation to the mainland for the purpose of furthering this work and in order to determine market possibilities, methods of manufacture, etc., covering the starch production industry. A large part of the United States was covered, investigations being made in States as widely separated as California, Massachusetts, and Florida. The experiment station and the extension division were primarily interested in this project not only for the above reasons, but because it promises to furnish additional means of livelihood for the small farmer; furthermore, after the starch has been extracted, the residual product can be made to serve as a valuable constituent of mixed feeds for live stock which now depend to a great extent upon imported feeds.

Preliminary investigations made with cassava and edible canna indicate that a profitable industry can be developed. Yields of cassava as high as 16 tons per acre, and of edible canna at the rate of 40 tons per acre, under ideal conditions as to soil fertility and moisture supply, further this possibility when one realizes that about 10 per cent of the edible canna and 25 per cent of cassava is commercially extractible starch. Cassava starch can be used commercially in sizing cotton goods, in the preparation of certain forms of adhesives, and as the source of tapioca. Because of its extraordinarily large starch grains, the edible canna has been declared superior to arrowroot starch for invalids; and it is thought that this product will, as a result, command a price sufficient to make its continued production profitable

In its further search for additional potential industries, the station devoted some time and attention to the development of methods of manufacturing various fruit and vegetable products, such as dried bananas, pickled fruits and vegetables, guava jelly, vinegar from pineapple waste, candies made up on a foundation of macadamia nuts, and the preservation of the avocado.

THE SECOND ANNUAL TERRITORIAL FAIR.

The success of the first Territorial fair, held in June, 1918, was due in large measure to enthusiasm developed by the war. While the second fair, held in June, 1919, did not receive the same stimulus, very effective work, surpassing that of the previous fair was accomplished by the county agents and other committeemen. The results of the agricultural extension work were manifested in the variety and quality of the agricultural exhibits shown. Among the exhibitors, keen competition was fostered by awarding cash prizes to those who displayed certain crops in which it was desired to arouse interest for their further development.

The second Territorial fair cooperated so splendidly with the experiment station in setting forth the desirability and possibility of diversified crop production that every available resource was temporarily devoted to bringing to a successful close those particular activities for which the station members had been made responsible by the fair commission. Each division of the station was represented by special exhibits, and most of the station staff held one or more committee assignments in connection with the various agricultural features of the fair. Acquaintances made during the food production campaign of the war period were turned by the station to its best advantage in developing enthusiasm among the various exhibitors.

The domestic science exhibits specialized on economical menus rather than on wheat and fat substitutes; the Japanese committee made a most creditable showing of numerous Japanese foods, daily changing its exhibits. The exhibit by the sugar plantations, of various industries which are receiving attention from them, was most commendable. One company exhibited the work of making cement from nonimported materials, and also demonstrated the practicability of obtaining from waste cane molasses a fuel which can be substituted for gasoline. Another plantation made an extensive exhibit covering its development of home-grown feeds for all classes of live stock. Among three exhibitors there was keen competition regarding mixed feeds which contained 50 per cent or more of home-grown products, such as pigeon-pea meal, velvet-bean meal, alfalfa meal, cane-top hay, waste molasses, cracked corn, etc.

HORTICULTURAL INVESTIGATIONS.

One of the more important features of the work of the horticultural division was that of the extension of Macadamia nut growing. About 1,000 seedlings were planted at various elevations throughout the islands. The few isolated old plantings of the Macadamia tree clearly indicate the chances of the successful production of this nut in the Hawaiian Islands.

Work with the avocado made material progress, and it is hoped that a greater interest can be aroused among growers to improve the many varieties of this fruit. Several small cooperative commercial orchards were started mainly to demonstrate the possibilities of the commercial production of the avocado. Sixteen new varieties of the Guatemalan type were received from the United States Department of Agriculture at Washington and planted for observation.

The station not only demonstrated varieties of mango best suited to conditions of the islands, but also started propaganda to further development of the superior strains. As a result numerous seedling trees throughout the islands were top-worked with improved strains, especially the Pirie, upon which the station is concentrating a good deal of attention.

The Solo papaya, which was under test, has proved to be a very promising strain. It has been brought to the fourth generation without deterioration in flavor or other desirable characteristics.

Investigations with the litchi tree were continued, and great prospects are looked for from the propagation of this exquisitely flavored fruit.

Considerable attention was also given to the coffee industry, which, owing to the prevailing low price of the coffee berry, is not in a flourishing condition.

Work with the propagation of pineapple seedlings was uninterrupted, and several thousand young seedlings were planted in commercial pineapple fields of different localities. A few of these are already beginning to bear fruit.

CHEMICAL INVESTIGATIONS.

One of the major projects of the division of chemistry throughout the year was that of drying and preserving Hawaiian vegetables and fruits. By the use of a drier, the working model of which was constructed on the station grounds, various tests were conducted with many island foods which were found adapted to preservation by drying. This drier, which is independent of weather conditions for effective results, is much more rapid in its action than the air drier, which was also kept in operation. By the use

of the small vacuum drier, exact data, showing rate of loss of moisture of the various crops, is readily had. This vacuum drier has also made it possible to obtain a better product of bananas and similar fruits, since the temperature and air pressure can be regulated and determined with much greater exactness than by other methods used.

The drying and preservation of fruits and vegetables, and the production of starch from cassava, edible canna, sweet potatoes, corn, taro, etc., have opened up commercial prospects which are receiving investigation from the experiment station and from various commercial interests of the islands.

AGRICULTURAL EXTENSION WORK.

The extension division, which has kept in close touch with the various agricultural projects of the islands, endeavored at all times to develop the most practical solutions of the many problems continually arising. The headquarters of the superintendent of the extension division are located at Haiku, on the island of Maui. The installation of an efficient telephone service has made it possible for him to keep in touch with the more remote and relatively inaccessible sections of the island.

Lectures, together with voluminous correspondence, and some practical demonstrations of caponizing, home curing of pork, etc., were effective in reaching large numbers of individual farmers. The promising showing made by the pigeon pea, edible canna, and cassava, justified the appeal made by the extension division to increase the production of these crops. Every assistance was rendered home and school garden activities, and some efforts were put forth to include corn clubs, calf clubs, etc., and to further the general development of this work. A pig club was recently launched on the island of Maui, the formal organization taking place in July, 1919, with about 31 enthusiastic young people in attendance. Steps were also taken to establish a farm bureau in each of the leading agricultural sections of the islands.

Nine collaborators were associated with the division during either the whole or a part of the year, one or more being located on each of the five larger islands. During the year the superintendent of the extension division made a trip to the mainland to investigate problems of production, utilization, and marketing of such starch crops as cassava and edible canna, and to determine at first hand the latest development in extension work.

On the island of Hawaii the extension work was materially furthered by the appointment on April 1, 1919, of R. A. Goff as director of extension for that island.

At the Haiku demonstration and experiment farm the best adapted varieties of both new and staple crops were demonstrated, and seed and planting material of these superior varieties were distributed to the farmers throughout the islands.

PLANT-DISEASE INVESTIGATIONS.

The division of plant pathology continued work to develop practical methods for overcoming diseases which infest the standard food crops of the islands. The major portion of the pathologist's time was taken up with investigations of the taro rot and the banana freckle disease. The banana freckle disease, which now threatens the entire industry, is a serious malady which first came under observation in 1917. Experiments carried on in cooperation with one of the leading banana growers resulted in the systematic spraying of a 75-acre field, which is now giving very promising results. An interesting series of observations was made on root rot troubles of bananas, pineapples, and sugar cane. So far these have yielded nothing sufficiently definite to justify publication at this time.

In addition to those reported on in previous annual reports, further miscellaneous plant diseases were observed and recorded.

AGRONOMIC INVESTIGATIONS.

During the year the agronomic activities of the station were concerned primarily with the most practical means of rapidly increasing the production of food and forage crops. This was brought about by the extensive distribution of seeds, cuttings, and tubers to all who had proper facilities for growing them. As soon as it became evident that the end of the war was near, the work of the division gradually shifted from the routine work of stimulating production to the improvement of those crops the standard varieties of which were already very well established throughout the islands.

Both the Guam and the Cuban Red corn have made splendid growth, though the former has given consistently higher yields on the station plats than the latter. However, the Guam variety, because of its white color, is locally at a disadvantage, inasmuch as the market favors a yellow variety of corn. Plans were, therefore, formulated for hybridizing the Guam corn with a variety of the desired color in the hope of combining the leaf-hopper resistant and other good qualities of the Guam corn with the yellow color demanded by the local market. It is considered more practicable to try to change the color of a variety of corn rather than to try to overcome the intense local prejudice of the several races against corn of a shade other than that to which they have long been accustomed.

Experiments with the sweet potato, one of the standard food crops of the island, were carried on to develop strains superior in

yield and possessing excellent market and table qualities. Great variation has already been noted in the seedlings which owe their origin in part to hybridization.

The station plats of edible canna and cassava have clearly demonstrated the value of these two root crops, and liberal distribution of these as planting materials were made. Fertilizer tests have given additional information regarding requirements of these particular crops under island conditions.

The work of the Castner substation was continued and, at the request of the Army authorities at Castner, a planting plan was prepared and submitted for the utilization of the species and varieties found to be most promising. Several days were spent by the agronomist in charge of the experiment station in locating a suitable site on the reservation for planting the more promising varieties on a much larger scale than was practicable at the Castner forage-crop substation.

POULTRY INVESTIGATIONS.

During the latter part of the fiscal year 1919 the station was fortunate in securing the temporary services of a poultry expert, L. M. Ross, who brought to completion a brief survey of poultry conditions in the islands. At present the most pressing problems with poultry are adequate housing, the provision of sanitary surroundings, and the proper methods of feeding, including properly balanced rations. It was found practicable to materially reduce the proportion of imported concentrates in the diet for island-raised poultry. Most of the poultry work of the station was conducted at the Glenwood substation on the island of Hawaii, but the present undertaking shows the need of conducting work on each of the larger islands.

GLENWOOD SUBSTATION.

The work of the Glenwood substation was directed largely to poultry and food crop production. The eggs were used for hatching purposes throughout the islands, and the surplus roosters were made available for breeding purposes. Experiments carried out in the past proved conclusively that potatoes, beans, cabbage, corn, and alfalfa can be successfully produced under Glenwood conditions, but that other standard crops are not ordinarily practicable. Among the successful minor crops were pohas, sorghum, edible canna, and pigeon peas. During the year 12 demonstration plats of alfalfa were established on the eastern side of the island of Hawaii. In many instances where very young seedlings were devastated by cutworms it became necessary to transplant the well-grown seedlings to fields. This was a laborious and expensive undertaking,

but the method will have proved a practicable one if the stands maintain themselves for a number of years.

In addition to attending to his regular duties at the Glenwood substation, the superintendent did considerable extension work in the immediate vicinity of the substation. In this matter it was found practicable to cooperate with the Territorial food commission and its county agents. The district immediately surrounding the Glenwood substation was taken over by the superintendent, who acted as its county agent. The remainder of the island of Hawaii was divided between the two Territorial county agents.

Ever since the establishment of the Glenwood substation the Territory has appropriated most of the money required for its maintenance. The 1919 session of the Territorial legislature, in response to the demand for the establishment of a similar station on the opposite side of the island, transferred its financial support to the prospective Waimea substation. However, it is planned to continue the Glenwood substation without financial support from the Territory, using such Territorial equipment as will not be required at the new station. The Glenwood substation will be run largely as a demonstration station and carry on such experimental work as can be provided from the funds at hand.

CHANGES IN THE STATION STAFF.

During the year there were a number of changes in the station staff. Maxwell O. Johnson, chemist, resigned March 20, 1919, to accept a position as industrial chemist with the Pearl City Fruit Co., Pearl City, Hawaii, at a large increase in salary. He was succeeded by Wallace Macfarlane April 9, 1919. H. L. Chung, assistant in agronomy, was absent in military service from October 15, 1918, to December 10, 1919, inclusive. R. A Goff, superintendent of the Glenwood substation, was appointed extension agent for the island of Hawaii on April 1, 1919. Temporary appointments were given L. M. Ross as poultry expert April 1 to June 30, 1919; E. J. Mooklar, assistant in fruit and vegetable utilization, November 25, 1918, to February 20, 1919; and P. L. Hesketh, assistant in market garden investigations, March 1 to May 31, 1919.

REPORT OF THE HORTICULTURAL DIVISION.

By J. Edgar Higgins.

The activities of the horticultural division were considerably affected during the year by war conditions. James H. Cowan, assistant in horticulture, who left to enter military service, almost immediately upon his return to the station on July 1, 1919, accepted

a position with the College of Hawaii as custodian of grounds. In the meantime no assistant in horticulture has been appointed. P. K. Lee, however, has rendered very valuable assistance in propagation work, in keeping records, in mapping permanent plantings, and in looking after much of the detail work.

While waiting further assistance an attempt was made to sustain, as far as possible, the line of work under way before the war started. Some attention was given to the Macadamia, or Queensland, nut as the basis of a possible new industry; and, on a trip to the island of Hawaii, certain phases of the coffee industry were investigated.

MACADAMIA NUT.

The Macadamia, or Queensland, nut (*Macadamia ternifolia*) (Pl. I, fig. 1), is one of the most promising of all nuts for improvement and for commercial cultivation within the Tropics or subtropics. It has received little attention, however, and in fact has been almost wholly neglected, notwithstanding the fact that it is unexcelled in richness and delicacy of flavor. This is one of the many obscure tropical products which should be brought to light, improved in some respects so as to be better adapted for commercial use, and thus be made to play an important part in feeding the world.

The tree is of upright growth, attains a height of probably 35 feet, has dark green foliage and rather dense head, and begins to bear when from 5 to 8 years of age. The nuts, which are incased in a hard shell one-eighth inch thick, are brown in color and about 1¼ inches in diameter. The kernel is perhaps three-fourths inch in diameter, nearly spherical or slightly flattened, white, and of a delicious flavor. It resembles the Brazil nut but is regarded by many as milder and more pleasing.

The trees of this species vary greatly in respect to productivity, size of nut, character of foliage, and bearing age. This is one of its splendid features, and gives rise to hope for great improvements by selection. One of the first changes brought about should be a softening of the shell, which is hard and thick. This feature probably is highly responsible for the failure of the nut to be more widely recognized and disseminated.

In a letter from Prof. Albert H. Benson, director of fruit culture for the department of agriculture of Queensland, it is stated that the thickness of shell varies considerably among the trees in their native conditions, and his observations have led to the conclusion that had the question of improving this nut been seriously taken in hand a comparatively thin shell would have eventuated ere this.

Another direction for selection and change is suggested by the fact that many of the seedlings have foliage possessing strong, spiny

teeth, while others are nearly free from this objectionable feature. Although the spiny character is not so serious a matter in a nut tree of this nature as in a tree from which the fruits must be gathered by hand, it is important nevertheless to eliminate such an undesirable feature. The spines greatly interfere with the comfort and convenience of the operator when pruning, spraying, and budding.

The experiment station is endeavoring to extend the trial of the Macadamia nut tree for propagation and permanence in Hawaii. This tree was introduced into Hawaii many years ago from Queensland by Messrs. E. W. and R. A. Jordan, the latter of whom secured the seeds in their native land. Specimen trees are to be found to-day in several parts of Honolulu and throughout the islands. The trees have prospered under the conditions in which they have been tried in Honolulu, and a few which bear each year are growing on the experiment station lands on Mount Tantalus, at an elevation of about 1,000 feet.

The division of horticulture grew about 1,000 trees from seeds collected at the Tantalus gardens, and kept them in readiness for planting during the summer of 1918. The station received the hearty cooperation of the trustees of the Bishop estate, and Mr. L. Macfarlane, manager of the Captain Cook Coffee Co., regarding the matter of planting these trees on a considerable scale in Kona. On September 3 a few trees were taken to Kona and later, when arrangements were about completed, a larger shipment was sent. These trees were planted out at different elevations ranging from 600 to 2,100 feet. The soil in which they were placed varies from typical rock land, where only pockets of soil are found, to open friable loam. The trees, which were placed under the care of a large number of tenants of the estate and of the Captain Cook Coffee Co., were in some cases planted adjoining each other so as to increase the probabilities of successful cultivation. The tenants themselves displayed great enthusiasm when learning that the trees were to be planted on their lands. All the trees with only two exceptions were placed among coffee plantings at distances of approximately 30 feet, the distance varying slightly with the method that had been followed in placing the coffee trees. The two exceptions referred to were where the Captain Cook Coffee Co. made plantings of trees 25 feet apart on land especially cleared for the purpose, and also where a few trees were planted in the neighborhood of the company's mill.

About 800 seeds of this species were sown at the station greenhouses in the latter part of the year 1918, and some time during the summer of 1919 the seedlings will be in readiness for transplanting.

THE AVOCADO.

Probably the avocado will always be one of the most important fruits grown in Hawaii. No export industry exists for the reason that the fruit is occasionally infested with the Mediterranean fruit fly, with the result that it is subjected to quarantine upon arrival at the mainland ports of the United States. Demonstration, however, has proved refrigeration to be a most efficient method for destroying the eggs, larvæ, and pupæ of the fly;[3] and, in fact, entomologists claim that this method could be used under careful government control to ship the fruit without danger of carrying the pest to uninfested ports. The following conclusions of Back and Pemberton,[4] reached after exhaustive study of the insect under refrigeration, merit very special consideration in this connection:

> The data contained in this paper show that no eggs or larvæ of the Mediterranean fruit fly survived refrigeration at 40° to 45° F. for seven weeks, at 33° to 40° for three weeks, or at 32° to 33° for two weeks. They may lead to the modification of existing quarantines and encourage the refrigeration of fruit subject to fruit-fly attack. It seems reasonable to conclude that sooner or later the certification of properly refrigerated fruit will be practicable. When an association of fruit growers or a people find it financially worth while there is no reason why they can not operate a central refrigeration plant under the supervision of an official whose reputation shall be sufficient to guarantee all fruits sent out from the plant to be absolutely free from danger as carriers of the Mediterranean fruit fly.

After a large quantity of fruits of uniform grade and variety has been produced to exceed local demands, an export trade to the mainland of the United States and Canada can be developed by the adoption of the refrigeration method. Larger productions of the avocado might result, too, in a trade with New Zealand and Australia and, possibly, without the refrigeration treatment of the fruit, since the Mediterranean fruit fly was well established there many years before it was found in Hawaii. The rapidly developing countries of the Orient must not be forgotten in this connection, for as the East becomes more closely united to the West, the avocado will become as popular there as it is now becoming in the United States. A further use for the avocado will be found in manufactured products. The division of chemistry of this station prepared the fruit in several ways and reported favorably upon a test with the bottled product known as Avocado Cocktail.

There is at present, however, a good demand in the local market for all the really choice avocados—a demand which will increase not only as the population grows, but as varieties and methods of packing are standardized. With this standardization the buyer will no longer have to risk getting unsatisfactory fruit, as now too often happens when he buys, but will know exactly what to expect from his

[3] Hawaii Sta. Press Bul. 47 (1914).

[4] U. S. Dept. Agr., Jour. Agr. Research, 5 (1916), No. 15, p. 665.

orders. Home consumption of the avocado can be easily increased three or four fold by encouraging the growth of those varieties whose fruits mature between October and May; during these months, the local markets are practically bare, except for some immature fruits which are rushed on the markets to obtain the prevailing high prices.

If the avocado were to be used for the home garden only, the high food value of the fruit and its intrinsic worth would justify all the effort that the station has given it and will continue to give it. In view of the larger possibilities of this fruit, it is to be regretted that even greater attention can not be focused upon it. One of the earliest services undertaken by the station was the adaptation of methods of propagation and the actual dissemination of budded trees which made it possible to establish nursery work on a commercial basis. Several of these small nurseries are now in operation where trees of the choicer varieties can be purchased and where one can engage the services of budders to top-work older trees. The station discontinued the practice of distributing budded trees and propagation is now being confined to some new varieties which are being tested in a few small cooperative orchards. With a view to testing their adaptability to heights, a small orchard of trees was planted at an elevation of about 1,000 feet at the station's gardens on Mount Tantalus.

A number of new varieties of the Guatemalan type were received from the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture. They represent a part of the valuable collection made by Mr. Wilson Popenoe, agricultural explorer, who spent many months in carefully exploring the highlands of that country in search of the most promising types of the Guatemalan avocado. These are of especial interest to Hawaii, because, like the Guatemalan varieties now grown at the station, their fruits will probably mature in the autumn and winter months when the more common West Indian type is out of season; furthermore, they will probably assist in extending the avocado belt to higher elevations in Hawaii, since they were discovered at altitudes between 4,000 and 6,000 feet above sea level. The new varieties recently introduced into Hawaii and their identification numbers are as follows:

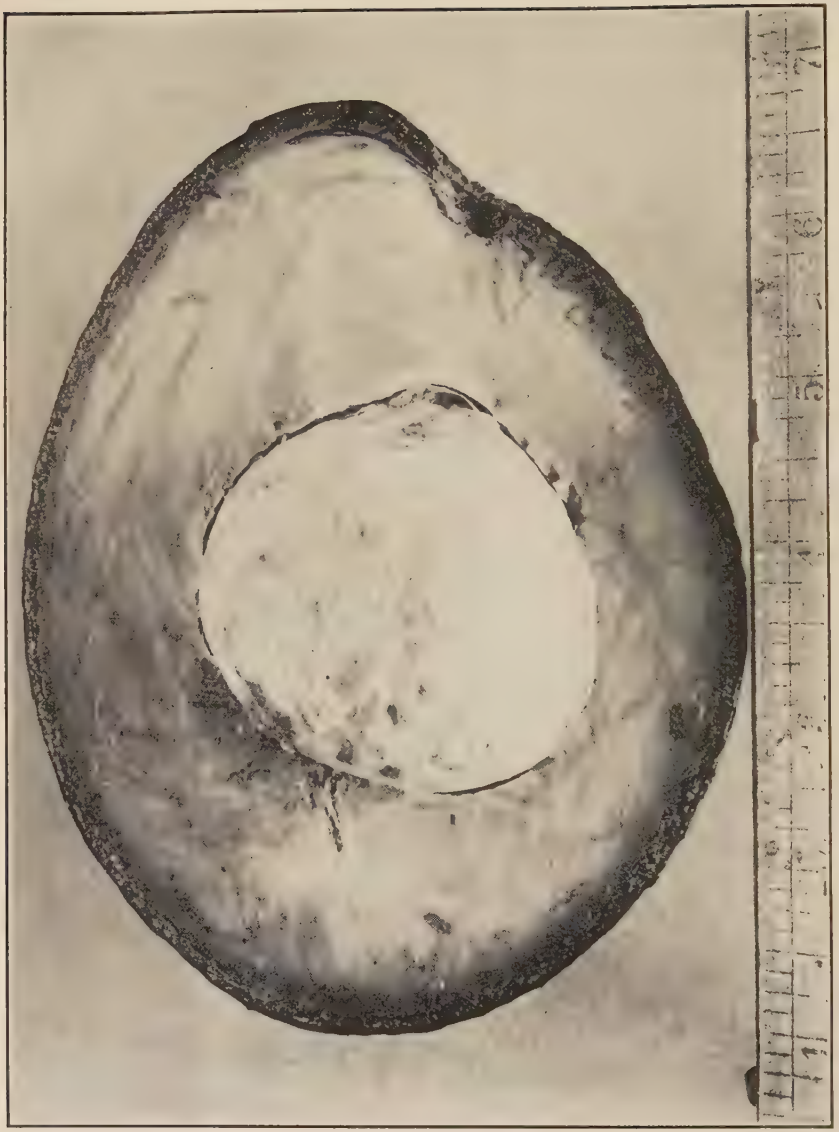
Varieties.	Hawaii Station number.	S. P. I. number.	Varieties.	Hawaii Station number.	S. P. I. number.
Lamat	4246	43476	Benik	4255	44626
Kanola	4247	43560	Mayapan	4256	44680
Ishkal	4248	43602	Manik	4257	45560
Kashlan	4249	43934	Cabnal	4258	44782
Pankay	4250	44785	Cantel	4259	44783
Nabal	4251	44439	Tertch	4260	44856
Nimlich	4252	44440	Ishim	4261	45562
Panchoy	4253	44625	Kanan	4262	45563
Tumin	4254	44627			

FIG. 1.—MACADAMIA NUTS; UNHULLED AND HULLED NUTS AND EXTRACTED KERNELS.

Diameter of plate, 4 inches.

FIG. 2.—THE PIRIE MANGO, A PROMISING VARIETY FOR HAWAII.

Diameter of plate, 10 inches.



THE BEARDSLEY AVOCADO.

Full descriptions of all these are being published in Washington by the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture, and copies will doubtless be available for distribution.

Of each variety, one tree was placed in the small orchard on Mount Tantalus, previously referred to, and others will be planted in different places for trial as they develop.

The Beardsley avocado.—This is a new variety of the Guatemalan type of Hawaiian origin (Pl. II). It is a seedling from the McDonald, one of the two original trees grown from seed first introduced into Hawaii from Guatemala[5] by Admiral Beardsley. Other seeds of the same type are said to have been left at Hilo and probably also on Maui. This new seedling was presented on December 18, 1911, to Mr. L. C. Ables, a careful cultivator who planted it in his home gardens at 1627 Kewalo Street, Honolulu, where the tree now stands. It is known to have produced a crop within four years after planting. The season of maturing the fruit varies, as is the case with all of this type, but it is strictly a fall and winter fruit. The tree is of upright and rather dense habit, a regular and prolific bearer. The fruit is the largest and most perfect of all the Guatemalan varieties that have come under observation at the experiment station. In honor of the benefactor, who introduced the seed of the parent tree, the first of its kind in Hawaii, and who, with much care, maintained their viability this, the best of the progeny that has appeared, has been named the Beardsley.

A description of the fruit in detail by J. H. Cowan, who made the record for the station, is as follows:

Weight 37 ounces, seed 15½ per cent, rind 13½ per cent, and edible portion 71 per cent. Shape round to pyriform. Fruit cavity, flaring, irregular, rounded, $\frac{5}{16}$ inch deep. Rind, a thick, hard shell of purple color on the surface when ripe. Pulp fine-grained with trace of fiber only at the base. Flavor, rich and nutty. Seed tight in seed cavity.

THE MANGO.

The present is an unusually good year for observations on the mango, as nearly all varieties in the station orchard are now in fruit, and other sorts have been brough in by private growers. A very important factor in mango growing is the wide variation shown by these fruits in their susceptibility to the attacks of the Mediterranean fruit fly. Fortunately, the Pirie, which gives promise of becoming the leading variety of all those introduced, and also some others of the choicer kinds are not attacked by the insect if other more attractive fruits are available.

In view of these facts, it would seem desirable to maintain with the choice varieties of mango, some other more attractive fruit, which

[5] Hawaii Sta. Bul. 25 (1911), p. 43.

would act as a trap in which to catch the flies. The susceptible varieties of mango would serve this purpose so far as diverting the insects is concerned; however, if these varieties are allowed to remain in the orchard, all fallen fruits must be picked up and submerged in water in order that the larvæ and pupæ of the fly may be destroyed. Unfortunately, the mango has been found not adapted to the several species of parasites introduced to destroy the Mediterranean fruit fly. According to Pemberton and Willard,[6] parasitism of fruit flies in the mango falls at times as low as 7 per cent of the total number of insects taken from the fruit during an entire month, while the average is uniformly low in the fruit. In coffee, which is a favorite fruit for the fly, there is a high percentage of fruit fly parasitism, running as high at times as 94 per cent. Were a variety of coffee to be found which ripens its fruits during the mango season, this could serve not only to protect the immediate crops, but also to greatly increase the number of parasites and reduce the fly. As above stated, there is in many localities a considerable assortment of fruit more attractive to the fly than the Pirie and some other varieties of mango. This interrelation of fruits, pest, and parasites should be kept in mind as it may frequently be found desirable to plant or graft in some fruit for the protection of the Pirie and of other choice varieties of mango.

The mango seed weevil (*Cryptorhynchus mangiferæ*) has become a very prevalent pest. Fortunately, it remains within the husk of the seed until some time after the fuit has ripened, and does not pollute the flesh of the mango or detract from its external appearance. Nevertheless, its presence within the seed often affects the appearance and even the flavor of a portion of the flesh surrounding the seed. In the case of the Pirie and some other good varieties, this injury is very slight unless the fruit is allowed to become overripe. The greatest injury is done to the seed, which, if allowed to remain within the husk, is usually destroyed. It is estimated that about 90 per cent of all the seeds opened at the experiment station this season were weevil infested and, therefore, unfit for propagation.

Various means are being tried to save the seeds from complete destruction. One of these consists in cutting open the husk as soon as it can be cleaned and slightly dried. When wet the husk is extremely difficult to cut, but when dried for about one day, it can be cut at the lower end at a point corresponding to the stigmatic point of the fruit; this cut may be extended up the ventral edge of the seed so as to permit the entrance of the thumb of each hand, with which the husk may be pried open and the seed removed. If the seed is found to be weevil infested, but not yet fully destroyed, the insects can be killed, the seed cleaned, and then planted. If the embryos of the seeds, many of which are polyembryonic, have been

[6] Jour. Agr. Research [U. S.], 12 (1918), No. 2, p. 106; 14 (1918), No. 13, p. 607.

destroyed, the seed will be useless, but should one or more of these remain uninjured, the seed can be expected to grow. Seeds planted without the husk require on an average 18 days to germinate, while those planted with the husk require on an average about 40 days to germinate.[7] It should be remembered that the only way to distinguish unsound seed is to open it. If such a seed were planted without having been opened, the long period required for germination would suffice for its utter destruction by the weevil within.

When a large percentage of the seeds has been found to be injured beyond the possibility of recovery, the removal of the seeds from the husks becomes a somewhat expensive though very necessary means of securing seedling plants. A less expensive, but less effective, method tried for the destruction of the insect consisted in making one rapid cut at the lower end of the seed as described above, after which the seeds were placed in a sack and submerged in water for one hour. Seeds so cut were also fumigated and, the weevil, which manifests a high degree of resistance, killed. The seed when cut open is moist within, but determination has not been made as to whether it can endure as much fumigation as the weevil will, or whether the frass or refuse created by the weevil will contribute to the decay of the injured seed.

MANGO VARIETIES.

This season has offered excellent opportunity not only for noting the local adaptability and characteristics of the mango varieties, but for establishing the synonymy of certain names. Lack of space prevents a detailed pomological description of each variety, but a few notes will serve to record the outstanding features of a number of them and to indicate those which seem best adapted to local cultivation or which are of most interest from the standpoint of breeding.

Pirie (Pl. I, fig. 2).—This variety is considered the best, at least for lowland conditions, of all the mangoes that have been introduced into Hawaii. It is of medium size, inclining to the rounded form, with a distinct beak at the stigmatic point. The surface is smooth and, when ripe, is a pale yellow beautifully marked with crimson where exposed to the sun. It is practically fiber-free, has a delightful aroma, and is as soft and juicy as a ripe peach. The seed is easily removed, so that the fruit can be served in halves and be eaten with a spoon without the slightest inconvenience. In order to remove the seed, it is only necessary to make a cut circling the fruit, about midway its length, and extending as deep as the surface of the seed. Then, by a slight twisting motion, one half of the fruit can be separated from the seed, leaving a smooth, unbroken surface within. By cut-

[7] Hawaii Sta. Bul. 12 (1906), p. 10.

ting very slightly around the seed, it may easily be removed from the remaining half of the mango. The flavor is so unusually delicious as to put this mango in a class of its own in Hawaii. The Pirie is less subject than other varieties to the black spots caused by the fungus *Colletotrichum glœosporioides*, and, while not immune to the fruit fly attacks, it either possesses a high degree of resistance, or is not a preferred variety for the fly. No injured fruits were found in this variety in the station orchards this season, though crops of several of the other varieties were rendered almost worthless.

Kavasji-Patel (*Cowasjee-Patel*).—This is one of the largest of the Indian mangoes introduced into Hawaii, being excelled in average weight only by the Sundersha. It inclines to the rounded form, is somewhat depressed on the ventral surface, and in color is pale green, which turns to yellow as the fruit ripens. The texture is excellent, but the flavor is somewhat inferior to that of the Pirie. The tree makes vigorous growth, but is a shy bearer.

Jamshedi.—This is a mango of large size approaching more nearly the spherical shape than most mangoes. It is of green color even when ripe, and has a good flavor and texture. The chief weakness of the variety seems to be its lack of attractiveness in color. The tree is a free bearer.

Mullgoa.—The Mullgoa is a large variety closely resembling Jamshedi, but distinguished from the latter variety by the large pale green spots which appear on the fruit.

Mulgoba.—This variety, which has proved so popular in Florida, has not attained prominence in Hawaii. The fruit is of medium size, being about the same in this respect as the Pirie. It is of good flavor and texture and is golden yellow when ripe, often splashed on the shoulder with red. The name has been considered by some as a probable synonym of Mullgoa, but it is a wholly different fruit, much more yellow and elongated.

Strawberry.—The tree, received under this name from India through the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture (S. P. I. No. 10643) seems to be identical with Pirie.

Peter's No. 1.—The variety received under this name from Trinidad, through the Office of Foreign Seed and Plant Introduction (S. P. I. No. 3706) also appears to be identical with Pirie. Doubtless the name is a more recent one than that of Pirie, which is an old established East Indian name.

Alphonse.—This variety has attained great fame in India, but, because of its lack of flavor, it has failed to become popular in Hawaii. It is of medium size and quite distinct in shape, being flattened on the ventral surface and without any prominent stigmatic point. The

Alphonse is indeed a handsome mango, being golden yellow in color and beautifully marked with crimson on the shoulder.

Hafu.—The Hafu is apparently a synonym of Alphonse.

Douglas Bennett's Alphonse.—Up to the present no consistent points of difference have been distinguished at the station between this variety and those received under the name "Hafu" and "Alphonse." However, a closer study of a large number of trees may reveal points of difference.

Ameeri.—The variety known as Ameeri is probably the most magnificently colored of all the mangoes introduced into Hawaii. It is elongated in shape and rather symmetrical, the exposed side being overlaid with a purplish hue, which changes to a gorgeous crimson on ripening, while its unexposed surface turns yellow. This mango is of good texture and fairly good flavor. The tree is vigorous and a good bearer. Because of its remarkable coloring, the Ameeri is well worth growing as an ornamental and should be of special interest to any plant breeder who desires to combine these color characters with the flavor or other desired characters of Pirie, which, though beautifully marked, has coloring less striking.

Brindabani.—The most prolific of all the mangoes that have been introduced is the Brindabani. The trees have been regular and abundant bearers, apparently devoting all their energies to the production of fruit. After they attain the bearing age they do not make rapid vegetative growth, though in healthy condition. The fruit, which is rather small and quite round, is green, the exposed surface being overlaid with dull brown or reddish tints. The flavor and texture can hardly be rated higher than fair, but it has the advantage of maturing very late, after most varieties have passed their season, and it is probably as nearly immune to the fruit-fly as any mango in Hawaii.

Totafari.—The Totafari is a handsome bright yellow mango, somewhat large, elongated, and rather symmetrical, with a prominent stigmatic point. It is of good texture, decidedly acid flavor, a reasonably good bearer, but quite susceptible to fruit-fly attacks.

Sundersha.—This is perhaps the largest mango in Hawaii. Its shape, which makes it unfavorable as a commercial mango, is very distinctly that of the letter S found also in the No. 9 mango quite familiarly known in these islands. The Sundersha is well colored and altogether a handsome mango, though not equal in flavor to some of the other varieties.

Divine.—This, the most inappropriately named of all mangoes, if judged by its performance in Hawaii, is of small size, extremely subject to the black spot disease referred to elsewhere, rather green in color, and well marked with red on the shoulder where not injured

by the disease. The flesh, which possesses only a fair flavor, is highly colored, of fair texture, and surrounds a rather large seed.

Cambodiana.—Cambodiana is of an entirely different type from any of the true Indian mangoes. It was received by the Office of Foreign Seed and Plant Introduction from Saigon, Cochin China, and is regarded by some botanists as a distinct species, to which has been given the name *Mangifera cambodiana*. Evidently to this type belong the numerous seedling varieties which have long been known in Hawaii under the name Chutney mangoes, sometimes spoken of as Chinese mangoes. All of these possess a distinct aroma, the foliage having a peculiar odor and a characteristic color and shape which distinguishes this type from the Indian varieties. The fruit of the Cambodiana is of medium size, beautiful golden yellow in color, and possesses a delightful subacid flavor in the highly colored flesh, which is of good texture and fiber free.

Wootten.—The Wootten is a variety of local origin belonging evidently to the Cambodiana type or to a cross between this and some variety of the Indian type. It is of medium to large size, of golden yellow color, slightly touched with red on the exposed shoulder, of good texture and rich flavor. One of the most important features of the Wootten, which permits its being marketed in an attractive condition, is the fact that the fruit remains hard while developing a remarkably good coloring. Some otherwise excellent mangoes fail to develop a good color until they are quite ripe.

Smith.—The Smith is another variety of local seedling origin and of the Cambodiana type. It closely resembles the Wootten, but it is earlier, of smaller size, and a little more highly colored on the exposed shoulder.

Number 9.—This is a variety, or perhaps more properly a type, introduced under this name many years ago by the government of the Hawaiian Islands. Many seedlings of it have appeared, most of them rather closely resembling the original type introduced. Practically all of these incline to the letter S shape, are very juicy, fibrous, and not highly flavored. The trees are abundant bearers, make vigorous growth, and produce handsome fruit rather free from the black spot disease.

Victoria.—The Victoria is a very beautifully colored variety of the No. 9 type grown by Mr. T. G. Thrum, Thurston Avenue, Honolulu.

Hawaiian Sweet.—This is more probably a type than a variety. It was the first mango, and among the early acquisitions of foreign fruits, introduced into the Hawaiian Islands, and was probably brought here by the late Don Marin. Few of its many seedling varieties, all closely resembling each other in shape and flavor, have been considered worthy of propagation by grafting or budding.

Oahu.—Probably the only seedling of the Hawaiian Sweet mango that has proved sufficiently distinct and valuable to cause it to be given a name and to be propagated by grafting is the Oahu. This remarkably handsome mango is large, possesses a mild and sweet flavor with abundant juice and has better texture than the average of its class. Many of the fruits show a tendency to be seedless, their husk containing no seed. This character, however, is not constant.

THE TOP-GRAFTING OF MANGO TREES.

Earlier reports and bulletins of the station described methods developed for the top-working of mango trees. Hawaii, however, is not a country of orchardists, and these methods were not applied as widely as they might have been had there been available someone who could be employed to do such work. The station, therefore, undertook, about two years ago, to forward this movement by detailing to the work on part time a man who had long been in training here. As the work developed, there appeared to be a large opening for an expert propagator in this and similar lines. The station, desiring to relinquish its operations as soon as assured that the work would be continued independently, and that owners of trees could get an experienced propagator to graft them, withdrew, leaving the work to be carried on as a private business by two men. In order to disseminate choice kinds of fruit the station supplies scions of the best varieties to these men or to any others who desire them. One of the most progressive of the large sugar plantations planted several hundred seedling mangoes along its avenue, and is having them grafted with choice East Indian varieties.

The very excellent crop of the Pirie variety this season made it possible to bring this fruit to the attention of the people by exhibitions which were held in prominent places in the city; and, at a luncheon given by the Honolulu Ad Club, its excellent qualities were demonstrated. This club has appointed a committee to aid in forwarding the movement for better mangoes in Hawaii, by means of substituting the Pirie and other choice varieties for the many inferior seedlings. As soon as the merits of these more recently introduced varieties become widely recognized, there will be a general movement to produce the best; the Territory will then be supplied, as it ought to be, with mangoes of real merit, and, should the quarantine regulations undergo changes suggested by Back and Pemberton in their above-mentioned discussion of the avocado, the exporting of mangoes may very easily become an important industry.

The station this season is conducting experiments in canning and drying the Pirie, and should either of these methods prove successful in producing a preserve which approaches the excellence of the

fresh fruit, an industry of very large possibilities would undoubtedly be developed.

THE SOLO PAPAYA.

This variety of papaya (Pl. III, fig. 1) which has been under cultivation through four generations, has transmitted its characteristic flavor and texture, and to a reasonable degree its shape, in all of the plants of its kind that have come under observation. To this variety has been given the name "Solo." It is quite small, in some instances the fruits permitting of only one serving; in others, the fruit is large enough for two servings. Most plants of the variety are hermaphrodite or bisexual, but a staminate tree is found occasionally. Although the fruits are small, they are crowded into the axil of nearly every leaf and are so numerous that the yield is reasonably heavy, yet not equalling in weight that of some of the large kinds. The fruit is pyriform, somewhat irregular, colors well and uniformly before softening, and is free from the diseased spots which attack the surface and penetrate the pulp of many of the large forms, The flesh is of medium thickness, of bright yellow color, smooth. tender almost to melting, and of delicious flavor even near the stem end where many papayas lack flavor. The seeds, which are abundant, permit of ready and rapid means of propagation, and, because of the loose placenta or inner lining of the fruit to which the seeds are attached, they are very easily removed when preparing the fruit for serving. From the standpoint of the home gardener, the Solo is considered one of the best of the papayas that have been grown at the experiment station, for, although small, its qualities of texture and flavor give it first rank. The Solo can be used as an individual fruit.

This variety is being quite widely disseminated throughout the Territory by the distribution of seeds and seedling plants. Several other kinds of papayas, under selection for several years, were also sent out in rather large quantities. The purpose of this distribution was to establish the best varieties in as many places in Hawaii as feasible, and also in other parts of the Tropics. Nearly every mail brings requests for seeds of the Hawaii Station selections. In general, it is possible to assign to each applicant only a limited quantity for trial and further propagation, but on one or two occasions where a hurricane had destroyed much of the vegetation, as was the case in the island of Guam, several pounds of seed were sent. In one or two cases, cooperative plantings were made where it was possible to keep them under close observation.

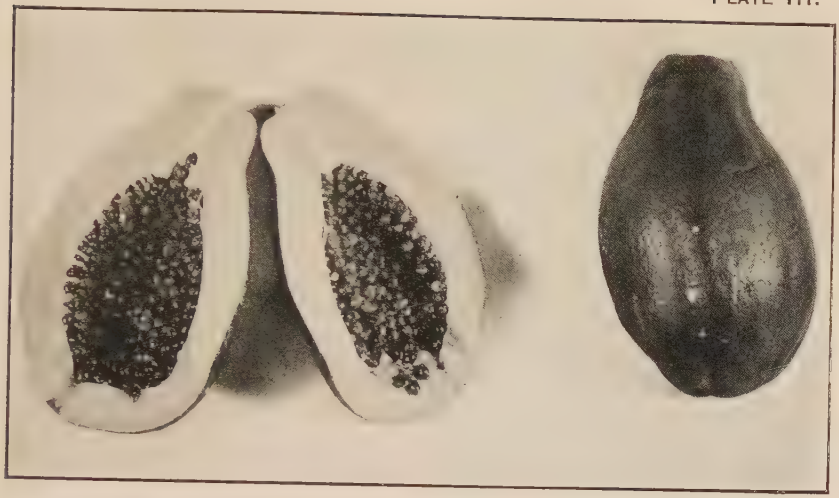


FIG. 1.—THE SOLO PAPAYA. LENGTH OF FRUIT 6 INCHES.

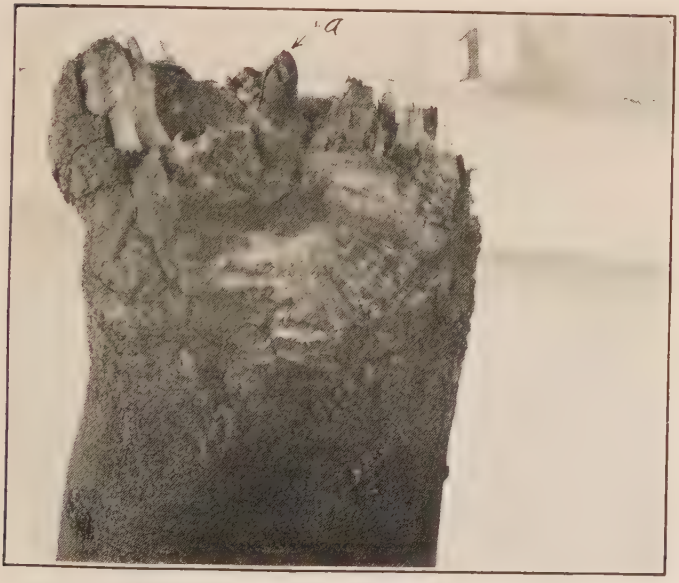


FIG. 2.—TRUNK OF LITCHI TREE BROKEN OFF JUST BENEATH SURFACE OF SOIL, SHOWING (*a*) DEAD STUB OF LAYERED BRANCH.

FIG. 1.—LONGAN TREE SHOWING INHERENT WEAKNESS IN STRUCTURE DUE TO MANNER OF ATTACHMENT OF BRANCHES.

FIG. 2.—BRANCH BROKEN FROM TREE FIGURED ABOVE, SHOWING MEAGER ATTACHMENT.

THE LITCHI.

It has not been possible to extend the investigations of the litchi as rapidly as was desired. The propagation of the varieties in the station collection is being continued. In the latter part of May, 1917, G. Weidman Groff, professor of agriculture in the Canton Christian College, Canton, China, arrived at Honolulu en route to Washington, D. C., bringing with him certain varieties of litchi plants intended for the Office of Foreign Seed and Plant Introduction of the United States Department of Agriculture. These varieties did not endure the journey well, and it was feared that a further trip of 5,000 miles would result in their total loss. The plants were, therefore, left in the care of this station where it was possible to restore to a growing condition the following varieties: Waai Chi, Kwei Mei, San Hing Heung Lai, Saam Uet Hung, Haak Ip, and T'in Naam. It was possible to cooperate with the Office of Foreign Seed and Plant Introduction also in aiding the further trial of the litchi in Florida by shipping to Washington in June, 1918, 25 pounds of fruit to be used for further propagating this species.

It is well known that the customary method of propagating the best varieties of litchi is that known as Chinese, or air-layering. This consists essentially in the removal of a ring of bark from a branch, and surrounding the wound with soil or moss which is kept constantly moist until root formation takes place from the upper or outer side of the wound. It is, however, questionable whether such a root system is ever as satisfactory as that produced from the growth of a seed. Plate III, figure 2, shows the stump of a litchi tree broken off just beneath the soil by the storm which occurred early in December, 1918. In the center of the wound may be seen, at the point *a*, the remains of the old branch which was layered to produce the new tree. This small piece of dead wood was simply the remains of the old branch from which the bark had been removed, and was of no service to the new tree after it extended downward beyond the root system. It will be seen that the root system was apparently very meager, although this tree had reached a height of 10 or 15 feet. Further observation disclosed the fact that the grain of wood at the point of junction between the roots and the stem was hardly favorable to strength of structure. It is often noticed when taking young litchi layers from a parent tree that only one or two good roots have formed. It is problematical whether further roots grow except those which serve as an extension and amplification for the roots present when the layer is taken from the tree. Whether or not an exhaustive study has been made of the root systems of air-layered litchi trees is unknown to the writer. It was pointed out in

an earlier publication [8] that the system of air-layering is likely to be superseded by the budding or grafting of the litchi on seedling stocks of its own, or of some closely allied species. Present observations on the root systems of an air-layered tree, suggest a further possible reason for developing other methods of propagation than that commonly practiced in the land of the litchi. In Bulletin 44, above referred to, reference was made to the temporary success of grafting the litchi on the longan. For more than a year these grafts remained in a flourishing condition, but later a peculiar condition developed which resulted in the failure of all the trees. This failure was attributed to incapability on the part of the litchi growth to sustain the longan stock upon which it was placed. Shoots were sent out by the longan, but these were persistently removed to encourage the growth of the litchi. In some instances large swellings were thrown out by the litchi branches, some distance above the point of union, suggesting the possible backing up or concentration of material at these points. Prof. Wilbur MacNeil, of the Oahu College in Honolulu, grafted scions of the litchi from this station into one or two branches in the top of a longan tree in his garden. This work was done at the time when the station trees gave promise of success. These branches continue to grow in the top of the tree surrounded by longan branches, a fact which bears out the theory that incompatibility between the stock and the scion is due to inability of the scion to nourish the stock.

The structure of the longan tree.—Attention is herein directed to certain observations on the structure of the longan tree. Although this species does not at present give great promise as a stock for the litchi, it is well worthy of cultivation for its own fruits. Plate IV, figures 1 and 2, shows the manner of attachment of the branches of the longan, and also a large wound caused by the breaking off of a branch under the stress of wind. A careful study of the attachment of the two remaining branches shown, and of the wound, will prove inherent weakness in the manner of attachment of the branches. It will also be seen from the wounded surface of the removed branch, as well as from the wound on the remaining branch, that there was practically no attachment above the point where the grain in the branch was parallel with the grain in the remaining limb. These observations point to the importance, when pruning, of selecting branches of the best possible attachment for the formation of the main framework of the tree and of the early elimination of branches that are very poorly attached.

[8] Hawaii Sta. Bul. 44 (1917), pp. 10, 11.

COFFEE.

In September, 1918, the horticulturist made a trip to the island of Hawaii for the purpose of investigating certain phases of the coffee industry of that island, especially regarding its status, its needs, both from an agricultural and from an economic point of view, and the availability of some of the by-products of coffee culture as possible sources of caffein.

As an introduction to notes relating to coffee, there is herewith submitted a brief review of the system now commonly used in coffee growing in Hawaii, and the process of preparing it for market, which perhaps may make more clear certain statements relating to by-products and also to the present conditions of the industry. Coffee is grown in Hawaii chiefly on the tenant-farm system. In the Hamakua district there is one large plantation which is cultivated by the owners with employed labor. This plan may be carried out to a limited degree by some planters in Kona, but for the most part the lands, in lots varying from 5 to 25 acres, are leased to small growers. In many instances, these lands are leased from the owners by coffee companies, these in turn subleasing them to others. A large part of the crop, while still in the cherry, is sold to the mills. A considerable portion also is pulped and dried by individual owners on small drying floors and later sold in the form of parchment coffee. The pulping is sometimes done by a small machine in a given locality for a small charge, when the coffee is returned to the owner for drying. The small growers do not attempt to remove the parchment, because the machinery required for this process is somewhat expensive, and some large growers prefer to hire this service rather than install the machinery for the work.

In Hawaii the process of preparing coffee for market is the one commonly employed for washed coffee. After it is picked, the coffee cherry is taken to the pulpers as promptly as possible, though it does sometimes remain in the bags for two days or more. It is then passed through the pulping machinery which separates the seed from pulp. The small machines consist of a roller having a rough surface. To secure a rough surface, the roller is sometimes covered with a sheet of brass through which holes have been made from the under surface. The heavier machine used in the mills consists of series of three or four rollers, the first of which crush and separate the larger fruits, and the later ones the smaller. The pulp is carried away by hand or by automatic carriers to a convenient place where it is allowed to ferment. After fermentation takes place, the pulp is used for fertilizer, and in the larger mills it is used in part for fuel. The coffee seed as it is separated from the pulp is covered with a sweet gelatinous substance which must be removed before the coffee can

be properly washed and dried. To facilitate its removal, the wet coffee passes to fermentation tanks where it is allowed to remain for 24 hours or more, after which it can be washed. In the larger mills there are revolving washing machines which churn the coffee with water and remove the gelatinous cover. The cleansed seed is then taken by automatic carriers, or, in the case of a small grower, by hand, to the drying floors where it is spread out for the first drying. Every precaution is taken to prevent rain from falling upon the beans. From time to time, as necessary, the seed is turned and stirred so as to prevent musting, and to hasten drying. At the mills, after the free water has been eliminated, by the first drying process, the coffee is taken by automatic carriers into the mill for more complete artificial drying, various devices being used for this purpose. When sufficiently dried, either by natural or artificial methods, it is ready for sale as parchment coffee. The outer husk or parchment-like cover is then removed, and the thin, soft covering, known as the silver skin, or waste material is separated from the cleansed coffee bean. The best machinery also grades the beans according to size, after which damaged beans are removed by hand from the best grains. On a large table, which is divided into compartments or bins, the beans are usually spread out sufficiently to make it possible to quickly find and remove the undesirable ones. In one mill at least, where machinery used for this process is under the control of the operator, a movable-belt table passes toward him, carrying a small quantity of coffee beans from which damaged specimens are picked out by hand. It is chiefly in this form that most Hawaiian coffee is marketed for export trade, though roasting, grinding, and packing are used to a limited degree.

Present status of the coffee industry.—The coffee industry in Hawaii, in addition to struggling for many years against competition with imported coffees grown on cheap land by low-priced labor, was, as a direct outcome of the war, completely cut off from many of the large markets of the world; prices dropped so low that coffee growers received less than in prewar times, and the cost of production was necessarily increased by the rise in the price of labor. Still more serious was the rise in the price of commodities which coffee growers need for their maintenance. Many of the growers are of oriental descent, and rice is their staple food. As one of the growers stated the condition: "Before the war three bags of coffee cherry would buy one bag of Japanese rice. Now it requires eight bags of cherry to buy one bag of rice." Rice advanced from $5 to $6 per bag to about $13, and coffee cherry fell from over $2 per bag to $1.65. While the American farmer on the mainland paid high prices for certain commodities, he received in return large prices for his agricultural pro-

ducts. The tide for the Hawaii coffee growers on the other hand was against him both in the price of production and distribution.

At the time of the present writing, June, 1919, the price of coffee has advanced to a price which breaks all recent records. This is, no doubt, due in great part to conditions brought about by cessation of war and the reopening of European markets, and perhaps also to frosts which are reported to have occurred in some of the coffee producing areas of Brazil. This rise in price probably came too late in the season to prove of immediate benefit to the producers, the sale of their crop being generally arranged in advance of the harvest season, or very soon thereafter because of shortage of funds. Should these high prices prevail through another harvesting period, coffee growers may expect to profit by the advance. Since, however, these prices can not be expected when normal conditions are restored, everything possible in the meantime should be done to assist this struggling industry of Hawaii.

Agricultural needs of the coffee industry.—Some years ago the green scale, *Coccus viridis*, menaced the industry; this pest is now however controlled by natural enemies. From an agricultural point of view there is no reason why the coffee business might not be greatly extended and it doubtless would expand rapidly were economic conditions to change in its favor. There is need, however, for experimental work along many lines. In Kona, one of the leading districts, no shade has been used on most of the plantings. Many of the trees have suffered no doubt for want of shade, but only after careful trial can it be determined where and under what conditions shade trees are needed, and what trees are best adapted to this purpose. The experiment station used a few trees of the *Inga laurina*, which were planted for trial by the Captain Cook Coffee Co., while the silver oak (*Grevillea robusta*), kukui (*Aleurites moluccana*), and others were tried to some extent by others. Very careful investigation, however, should be given the subject of shading so that definite data will be available.

Pruning of coffee trees in Kona, Hawaii. -In Kona no very definite method of pruning coffee trees is practiced by most growers. Pruning experiments are needed to determine their relation to shade, to varying distances required for planting, to ascertain individual differences in trees, and also to discover their relation to prolonging the life and increasing the productivity of the trees. The trees were planted at distances varying from 4 or 5 to 10 feet apart; the tendency appears to have been that of too close planting. Another matter needing immediate attention is that relating to proper distances in planting. Many of the older trees, where planted very close, have grown to great height for light and air and practically their only

bearing surface is on top. Only a small bearing surface has been the result, therefore, despite the fact that a large number of trees were planted to the acre. Some experiments might be well worth while in order to determine whether it would be practicable to restore these old trees to health and productivity by some renewal system. Fertilizer experiments are also needed in order to determine their most effective and economical use.

Another promising field for experiment would be to select trees of unusual vigor and productivity and propagate them by asexual methods so as to develop greater uniformity. These methods of propagation might also prove of value in top-working old plantings to a superior strain. At present there are only two recognized commercially grown varieties in Hawaii, one known as the Hawaiian coffee, the progeny probably of a very early introduction, and the other the Guatemalan, which was introduced 20 or 30 years ago during a time when coffee growing was prospering.

Budding and grafting experiments.—Certain simple trials in budding and grafting, along the lines just indicated, were undertaken by the writer during a brief stay in Kona. Mr. L. Macfarlane, manager of the Captain Cook Coffee Co., called attention to a few trees of the Maragogipe variety of coffee grown for trial from seeds introduced by him some years ago. This variety of coffee was discovered in Brazil about 1870. It produces a large berry and large bean, commands fancy prices and is well worth very careful trial in Hawaii. Mr. Macfarlane secured the variety in Mexico, where it is grown to some extent. Buds from this variety were inserted on the main stem of some 2-year-old trees, and also on a few suckers in the upright-growing branches of older trees. Scions were also taken from this variety and were inserted as cleft grafts and also as bark grafts on the main stem of 2-year-old trees and also on the large upright growths of older trees. Coffee trees make two distinct forms of growth, the upright and the lateral. It has been found that coffee buds taken from the lateral growths continue to produce lateral growth in the new trees on which they are placed, and it is only by the use of the dormant buds subtending laterals on upright growths that it is possible to secure a normal upright budded or grafted tree. A letter from Mr. Macfarlane concerning the outcome of this work, which was performed shortly before leaving Kona, indicates that the budding was quite successful on the younger trees but on the older stocks grafting succeeded better than budding. However, the work was on too small a scale to justify any general conclusions as to the best methods of propagation, and should be regarded as preliminary to further experiments which may be carried on.

Coffee by-products.—In a letter from the Chief of Insular Stations, States Relations Service, United States Department of Agriculture,

it was requested that the practicability of recovering the caffein in coffee pulp, prunings, etc., be investigated in Hawaii. The following extract of a letter from Dr. Frederick B. Power, pharmaceutical research chemist in charge of Phytochemical Laboratory of the Bureau of Chemistry, United States Department of Agriculture, presents the problem:

> This laboratory has for some time been interested in the question of the utilization of sources of caffein other than those heretofore employed. A preliminary examination of coffee leaves and coffee pulp obtained from Porto Rico have shown that they both contain appreciable amounts of caffein. It would be of interest to us to know to what extent such material would be available and at what period of the year the leaves and pulp could be obtained.

An investigation was made in Kona and in east Hawaii to determine the amount of such materials as might be used in this way, and also their present uses and the possibility of their availability for the proposed purposes. These two districts comprise nearly all the coffee-growing parts of the Territory, the remaining scattered portions producing probably less than 5 per cent of the whole crop.

Kona and east Hawaii produce approximately 50,000 bags of clean coffee per year, more than 80 per cent coming from Kona. About 6 bags of coffee cherry, or 600 pounds, are required to yield one bag, or 100 pounds, of cleaned and dried coffee. This means that of the 30,000,000 pounds of coffee cherry produced, 5,000,000 pounds are marketable coffee. It requires 120 pounds of coffee in the parchment to make 100 pounds of clean coffee ready for market, the loss of 20 pounds representing the horn skin, or parchment, the silver skin, and an occasional bad bean. For every 500 pounds of marketable clean coffee there have been eliminated 100 pounds of this waste material. There are, therefore, approximately 1,000,000 pounds of this dried material produced annually.

The proportion of weight of pulp to the entire weight of cherry has not yet been carefully worked out at the coffee mills, since there was no special reason for determining it, and further because water is usually added in the pulping process. From two 10-pound samples of coffee cherry gathered from the station plantings on Mount Tantalus it was estimated that the pulp constituted approximately 47 per cent, including the water lost in the pulping process. The wet beans represented 53 per cent of the whole and the pulp contained 80 per cent water. The proportions of pulp and of moisture in the pulp would vary with different climatic conditions, and with the different varieties of coffee, but these figures are only approximate.

From the 30,000,000 pounds of cherry there would be 14,100,000 pounds of pulp. Of this, 20 per cent, or 2,820,000 pounds, represents the weight of dry matter.

To summarize, it may be said that at present the by-products from the coffee cherry in Hawaii are about as follows:

	Pounds.
Parchment and silver skin	1,000,000
Pulp:	
Containing 80 per cent moisture	14,100,000
Moisture free	2,820,000

This material, if desired, could be secured chiefly in the late summer and the autumn when the crop is being gathered and milled. It is difficult to estimate the weight of prunings that might be available for the purpose of caffein extraction. Many of the plantations or coffee farms do very little pruning; a few others prune quite systematically. At the present time there may be 2,000,000 pounds of prunings, but this amount would increase manyfold were the material to be sold at a price high enough to pay for the cost of the labor. While the advantages of judicious pruning are recognized in Hawaii, the prevailing precarious conditions of the coffee business has caused growers to hesitate to undertake the expense of pruning, particularly now that labor is so high and difficult to secure. Those widely scattered prunings now available are practically waste and they can be secured for little more than than the cost of gathering.

The dry products, silver skin and the parchment, generally used for fuel, are considered waste products at some of the mills. These could probably be available for the extraction of caffein if this operation proved profitable. The silver skin and parchment are centered at some of the half dozen mills in Hawaii.

The pulp is used in part as fuel, but the most of it is returned to the soil to act as fertilizer. Its value as fertilizer probably would be a criterion of the price required to secure the material for some other use. In November, 1911, an analysis of coffee pulp as a fertilizer was made by Mr. S. S. Peck, at that time chemist of the experiment station of the Hawaiian Sugar Planters' Association. Through the courtesy of Mr. P. S. Burgess, chemist of that station, a copy of the analysis made is submitted herewith.

Analysis of coffee pulp.

	Moisture free.	Original material.		Moisture free.	Original material.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Water	.....	62.00	Potash	3.91	1.49
Phosphoric acid	0.54	.21	Total ash	9.97	3.79
Nitrogen	2.18	.83			

In addition to the actual content of its fertilizing constituents, coffee pulp is thought to be quite valuable as an amendment to the soil. In a tropical country where humus is rapidly depleted from a soil that is kept constantly under cultivation it is important that the

value of the pulp as a substitute be considered. Coffee pulp is much more widely scattered than parchment and silver skin because many small growers do their own pulping with hand pulpers or by those operated by gasoline engines. A considerable portion of the pulping work is, however, centered at two or three mills.

VANILLA.

Some attention was given to the present status of vanilla cultivation in Kona, where two or three attempts were made to establish an industry. Capt. R. V. Woods is successfully producing vanilla beans and an extract of fine quality. In another part of Kona a large number of healthy vines were found climbing onto trees in a tropical jungle where an extensive vanilla plantation had been abandoned. Were a number of cuttings from these plants disseminated for trial among coffee growers and others they undoubtedly would make thrifty growth in some parts of the Territory even better adapted to the needs of vanilla than Kona. The plant requires humidity and heat, and Kona is inclined to be cool in most of the humid parts. The vicinity of Hilo or the Puna districts of the island of Maui probably would prove favorable spots for future tests.

PINEAPPLES.

The propagation and planting of seedling pineapples was furthered and several thousand of the young seedlings were placed in the commercial pineapple fields of different localities. A few of the first plantings made under these conditions are now beginning to fruit. Interest in the growing of pineapple seedlings developed to a remarkable degree and the work was entered into by the Hawaiian Pineapple Packers' Association on a scale exceeding the financial means of this station. It is gratifying to see this promising work being developed in such a vigorous manner.

THE ALGAROBA TREE AND RELATED SPECIES.

A number of species of Prosopis, introduced as seeds from several parts of the American tropics, were planted on the station grounds, where they are under close observation. Some of these are about to begin to fruit, and the character of their fruit and foliage will soon be apparent. Several thousand seedlings were grown from the seeds of selected trees in cooperation with plantings made by those who are interested in the algaroba-bean industry as a source of ground feed for stock. Some of these were distributed on the other islands of the group, and near Honolulu, where a large planting was made, plans for future observations are under way.

NEW OR RARE PLANTS.

Through the kindness of Mr. John Scott, of Hilo, the station was presented with a number of fruits from the only bearing tree in Hawaii of the ivory nut palm (*Œlococcus carolinensis*). These nuts, which are illustrated in Plate V, figure 1, are the source of a material which is known as vegetable ivory, and which is frequently used in the manufacture of buttons and similar products. Although this tree will probably be of little, if any, economic importance to Hawaii, it is of considerable interest as an ornamental and as a specimen of an economic plant. Some of these seeds are sprouting in the station greenhouse despite the fact they are said to be difficult of germination.

The Mandarin vine (*Holmskioldia sanguinea*), which was collected by the horticulturist in Porto Rico in 1914, is proving to be a valuable acquisition to the ornamental plants of Hawaii. While it is naturally a climber, it can be grown without support. From a distance its handsome, brick-red colored bracts suggest the brick red variety of the bougainvillæa.

Among the other new or recently introduced plants are a superior variety of Chinese jujube (*Zizyphus jujuba*); Paraguay tea (*Ilex paraguayensis*); a timber bamboo (*Phyllostachys bambusoides*); several varieties of pineapple; several species of Cinchona, which furnish the cinchona or Peruvian bark, the source of quinine; several species of citrus relatives; snake gourd or Guada bean (*Trichosanthes anguina*); and several varieties of mulberry.

HORTICULTURAL EXTENSION WORK.

A large part of the time of the horticulturist is at present required in extension-work activities. During the past two years some of these were carried on in connection with the annual Territorial fairs, one of the main objects of which was to foster and further interest in local production so as to increase the food supply of the island. The exhibit of the horticultural division, which occupied one side of the station booth, showed some of the more recently introduced plants, the methods pursued in propagating pineapples from seed, a number of tropical fruits which were preserved in exhibition jars, the method pursued in growing strawberries in a barrel on small city lots, Macadamia nuts shelled and unshelled, and served as a confection after having been prepared by dipping in chocolate or in fondant; and sundry other features illustrating the work of the division.

During the few months preceding the fair, the attention of the horticulturist was directed chiefly to activities of the several committees on fruits, vegetables, field crops, and flowers. This year, in connection with the prize contest conducted by the Honolulu Star-Bulletin with the cooperation of the department of public instruction, he again acted as one of the judges of school and home gardens of the

children on the island of Oahu. It is gratifying to be able to record that since this work was begun there has been a marked improvement in the gardens both at the schools and at the homes. Some of the children walked miles in order that they might take advantage of the plats available for their gardens; in some cases, not only tools and manure were carried long distances, but daily trips were made so that the plats might receive watering and other cultural attention, and many young people carried the produce on their backs to a suitable marketing place.

The writer, while on a trip to the island of Hawaii, elsewhere referred to, made observations on the progress of the island's food production, and gave demonstration lessons in budding and grafting to some of the collaborators of the station and to others who would impart the knowledge. An increased interest in food production work was aroused among plantation owners, and laborers, homesteaders, and the planters of small holdings, and suitable opportunities presented themselves in many parts of the island for the further distribution of food crops, especially the selected varieties of sweet potatoes, cassava, edible canna, and papaya.

On the Parker ranch, at Waikii, splendid work in the production of about 3,500 acres of first-class corn was accomplished, and Mr. A. W. Carter, the manager, estimates the weight of corn produced equal to the entire importation of wheat flour in Hawaii during the last year.

It was noted that all along the Hamakua coast and in Kona plantings of upland taro were being made as rapidly as it was possible to secure this stock for propagation; this bespoke interest and enthusiasm in a material which had not only advanced in price, but was hard to secure.

One of the most interesting observations in Kona was that of the successful growing of squashes, pumpkins, watermelons, and even muskmelons. For the last 20 years it has been impossible to grow muskmelons or cantaloups in the Territory because of the devastations which resulted from attacks of the melon fly. The parasites introduced to control this insect have proved a success in this respect. Entomologists attribute the fact to prevailing excellent conditions which tend to aid its work. In almost every part of the district there is found a cucurbitaceous vine known as the wild cucumber (*Momordica charantia*), the fruit of which acts as a favorite host for the melon fly. Fortunately, it is a fruit into which the parasite can penetrate and find the larvæ of the fly. This wild plant functions as a trap into which the melon fly lays its eggs, which are destroyed in a later stage of their development.

The Kona orange is again coming into its own after having suffered from scale-insect and fruit-fly attacks. Citrus trees thrive very well

in Kona. In fact, it is doubtful whether any other part of this Territory gives greater promise for the successful cultivation of the finer varieties of oranges, grapefruits, lemons, and limes. It would be worth while to increase the planting of all of these kinds of citrus in Kona.

The station is confining the distribution of seeds and plants, as far as possible, to a few sorts which it has produced, or to those considered most important for general growth, and which can not be readily obtained elsewhere. Many thousands of seedlings of the station variety of tomato bred as a resistant to the melon fly, and an equally large number of papayas of the station variety were distributed. The practice of the station has been to disseminate seeds of these new varieties rather than the plants, except where only a few plants can be grown, as on small city lots.

The burden of extension-service work was further enhanced by a daily increasing number of telephone and letter inquiries for information covering a wide field of horticultural and related subjects.

REPORT OF THE CHEMICAL DIVISION.

By Maxwell O. Johnson and Kim A. Ching.

As food shortage conditions prevailed during the greater part of the fiscal year, the chief work of the chemical division consisted of studies of means and methods for the preservation and utilization of food. Experiments were made in drying and canning local fruits and vegetables. Investigations covering the manufacture of starch from a number of different local sources were made, and the manufacture of vinegars received much attention. Vinegar, which when tested surpassed the required local standard (4 per cent acetic acid), was successfully made from pineapple juice. A number of analyses were made of home-grown feeding stuffs and of soils, and an extensive fertilizer experiment with bananas was started. The investigations on the biochemical effect of manganese were continued.

DRYING HAWAIIAN FOOD PRODUCTS.

During the past fiscal year experimental work in drying was greatly facilitated by the completion of a large tower drier and the installation of a small vacuum drying system. The tower drier holds trays 3 feet wide by 4 feet long. A blower, driven by a small gasoline engine, forces air around steam coils and up through the trays in the tower. Regulation of temperature can be had by varying the number of steam coils used, and by altering the steam pressure. The velocity of the air can be controlled by changing the speed of the blower. Experiments were run on a semicommercial scale with this drier and

satisfactory results were obtained. In the following table is shown the percentage of dried fruit and vegetables obtained from the tower drying system:

Yield of dried fruit and vegetables produced in tower drier.

Materials.	Weight of original.	Weight of peeling.	Weight of peeled root or fruit.	Weight of dried product.	Dried material from original.	Dried material from peeled root or fruit.	Moisture loss.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Per cent.*
Sweet potato	200	39¾	160¼	53	27.0	33	67.0
String beans	10	.....	.....	1½	14.4	.....	85.6
Carrot	8½	.....	.....	1¼	15.1	.....	84.9
Turnips	5¾	.....	.....	½	7.6	.....	92.4
Cabbage	8	.....	.....	⅞	11.2	.....	88.2
Cucumber	9½	.....	.....	⅜	4.8	.....	95.2
Pineapple	38	10	28	5⅛	13.4	18.3	81.7
Papaya	8½	1⅛	7	1⅛	11.5	13.4	86.6
Mango	7½	[a] 4⅛	2⅜	1¾	23.3	66.6	33.4

[a] Peeling weight, 2⅛ pounds; seed weight, 2¾ pounds.

PRESERVING HAWAIIAN FOOD PRODUCTS.

A number of unsuccessful attempts were made to preserve the avocado fruit, as when heated, to sterilization temperature, the fruit developed a very bitter disagreeable flavor. The best method employed so far was that of cutting the peeled halves into small cubes, handling them meanwhile as aseptically as possible. After this the cubes were placed in a sterilized jar, which was filled with an ordinary commercial tomato cocktail sauce heated to the boiling point. Avocado preserved in this manner has kept in good condition for a year.

Papayas may be preserved in a manner similar to the avocado, or the two fruits can be combined.

Experiments were also made in the utilization of pineapple juice, which is a waste product of the canning industry. By mixing and boiling down equal parts of clarified pineapple juice and guava extract, a very good jelly, which was considered greatly superior to ordinary guava jelly, was obtained. Pectin precipitated from guava extract by alcohol and added to pineapple juice made a good jelly after being boiled down. Experiments were made in concentrating pineapple juice by freezing. This method, which gave good results, consisted in freezing the juice in an ice-cream freezer and separating the concentrated juice by centrifugal action.

MANUFACTURE OF STARCHES.

An attempt was made to manufacture starch from pineapple stumps. Extraction of the starch was made by grating the stumps, which contained many hard fibers. Because of a slowness in settle-

ment, due to the fineness of the starch grains, some trouble was experienced in separating them from darker woody particles. About 2.5 per cent of starch, based on the weight of the stump, was obtained.

Starches were also extracted from the root crops of taro, sweet potato, edible canna, Irish potato, cassava, and from Guam corn, rice, arrowroot, banana, and tree fern. Results of these experiments are being prepared for publication in bulletin form.

MANUFACTURE OF VINEGARS.

In a previous report of this station[9] a former chemist stated that experiments with pineapple juice were made for the manufacture of vinegar, but that it was found impossible to make a product which would comply with the legal standard requirement for acidity.

Experiments with pineapple vinegar were conducted during the past fiscal year. A pineapple juice, testing 11° Brix, was secured from one of the pineapple canneries. This was heated to boiling, poured into a carboy plugged with cotton, and, on the following morning, inoculated with common bread yeast. Very active fermentation took place, and by the third day the juice had settled. Samples taken on the fifth day showed an alcoholic content of 5 per cent. The product of fermentation was a cider-colored clear liquid which was poured off from the settlings. After some difficulty was experienced in obtaining active vinegar bacteria, a fairly active cider vinegar was secured and mixed with the fermented juice in parts of 1 to 4 and 1 to 8 of the juice. The mixtures were placed in glass vessels having cheesecloth covering. Two and a half months later a very active vinegar fermentation had taken place and a heavy layer of mother of vinegar had formed. The mixture of 1 part to 4 of juice contained 4.2 per cent of acetic acid, and was pronounced of fine quality by local experts. There should be no longer any difficulty in the manufacture on a commercial scale of vinegar from pineapple juice, especially now that active cultures of vinegar bacteria have been secured, and a quick process can be had by means of vinegar generators.

ANALYSES OF FEEDING STUFFS.

The following analyses have been made as the result of considerable interest manifested in the development of local sources of supply of feeding stuffs:

[9] Hawaii Sta. Rpt. 1913, p. 34.

Chemical analyses of some Hawaiian feeding stuffs.

Feeding stuff.	Water.	Ash.	Crude protein.	Carbohydrates.		Fat.
				Fiber.	Nitrogen-free extract.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Pigeon pea meal (stem, leaves, and pods)	11.9	2.96	9.21	38.73	34.53	2.67
Coconut meal	10.7	6.09	17.15	11.14	44.13	10.79
Fiber from pineapple stump after starch extraction	10.83	.91	3.5	15.12	68.98	.66
Mixed feed	13.31	8.11	8.57	12.58	54.64	2.79
Brazilian velvet-bean meal (stem, leaves, and pods)	10.20	6.48	6.21	12.69	62.91	1.51
Fiber from good pineapple plant after extraction	9.73	2.07	3.67	17.20	65.74	1.59
Sisal stump	76.7	1.29	.35	7.07	14.26	.33
Cane top meal	7.05	5.85	4.72	31.48	50.05	.85
Alfalfa meal	8.37	3.89	14.86	28.88	41.63	2.37
Mung bean (*Phaseolus radiatus*)	13.06	3.88	24.67	4.41	52.68	1.30

FERTILIZER EXPERIMENTS WITH BANANAS.

During the past three years fertilizer experiments with bananas were carried on; solutions containing fertilizing salts were used as sprays, and various mixtures of the more insoluble fertilizers were applied to the axils of the leaves. In March, 1919, a new planting of about 5 acres was made at Mokuleia, Oahu, and utilized as a large fertilizer experiment. Most of the fertilizer experiments were based on the triangle system which seems to be one of the best methods proposed for this purpose.

The first application of fertilizer was made in April, 1919, and it is planned to make this experiment continuous so that results will be secured on successive ratoon crops as well as on the first crop. Should a fertilizer producing good results be secured, it will be of great benefit to the grower, who profits principally from the shipment of large bunches of bananas, the smaller bunches being of little commercial value.

FERTILIZER EXPERIMENTS WITH PINEAPPLES.

Fertilizer experiment on pineapples, mentioned in last year's report,[10] made by applying various mixtures of the more insoluble fertilizers directly to the heart of the plants, is progressing and the plants are now producing fruit. Dried blood applied in this manner gave the best results, and a fine stand of fruit, superior to the check rows on either side, is developing. Fish scrap, which was applied in the same manner, produced very dark green healthy plants. Unfortunately, the last application was made at a time when some of the plants were budding and as a consequence the fruit was more or less distorted and injured. Steamed bone meal produced small but positive benefit.

[10] Hawaii Sta. Rpt. 1918, p. 24.

MANGANESE INVESTIGATIONS

In the report for 1918[11] a description was given of an experiment on manganese soil to which sulphur, at rates of 500 to 3,000 pounds per acre, a red very acid soil at rates of 1 to 6 tons per acre, and bagasse soaked in strong solution of iron sulphate at various rates, had been applied. None of these soil treatments were successful in supplying iron to the pineapple plants, and those on the treated plats became chlorotic at the same time as the checks. After spraying the whole plat with the iron sulphate solution,[12] however, the plants became green and healthy in a short time. It is a fact worth noting that applications of iron sulphate to the soil, at rates varying from 500 to 3,000 pounds to the acre, were unsuccessful in preventing chlorosis, yet the spraying treatment in which considerably less than 50 pounds of iron sulphate per acre was applied to the leaves, promptly cured the chlorosis. The application of the iron sulphate to the soil was effected by soaking bagasse with the iron sulphate, then applying the soaked bagasse and incorporating it in the soil.

REPORT OF THE AGRONOMY DIVISION.

By H. L. Chung.

The agronomy division accomplished good work during the fiscal year 1919, dealing primarily with the emergency food crops for man and animal. The work covered included breeding, fertilizer experiments, variety testing, and distribution of planting stocks of new improved varieties.

CORN.

During the past year two varieties of corn, the Guam and the Cuban Red, have been under test at the station in Honolulu. They represented the two strains selected from a number of varieties for ideal type and yield. The Guam variety produced at the rate of 52.5 bushels to the acre in 1919, an increase of 5 bushels over the crop of 1917–18, while the Cuban Red yielded at the rate of 30.4 bushels.

The Guam variety was characterized by prolificacy, two or three ears appearing on a single stalk. Both varieties, however, were wanting in the desirable length of the ears. This defect, in large measure, was responsible for their low yield. It is thought that constant and careful selection will eventually result in ears developed to the desired length.

While the Guam corn appears to be one of the most resistant varieties to conditions as far as the leaf hopper in Hawaii is concerned, its market possibilities are and will be limited as long as the cosmo-

[11] Hawaii Sta. Rpt. 1918, p. 24. [12] Hawaii Sta. Press Bul. 51 (1916).

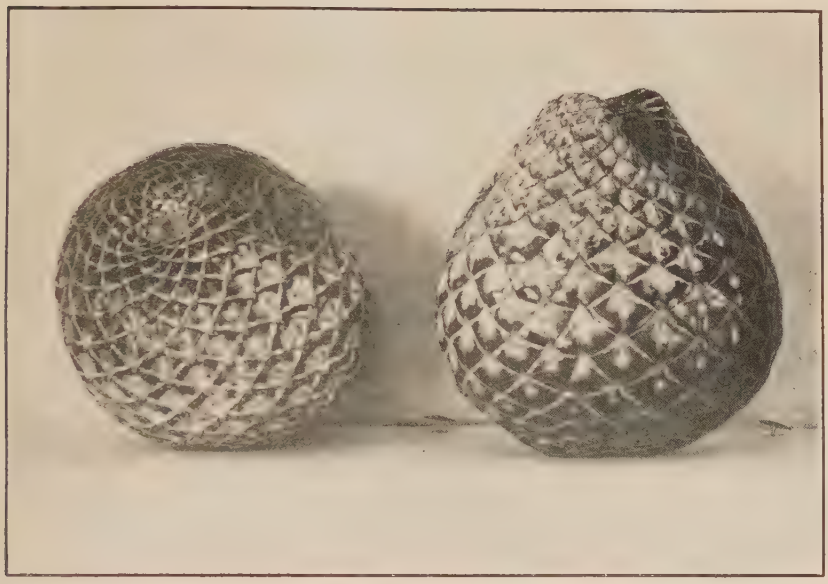


FIG. 1.—FRUIT OF IVORY NUT PALM (CŒLOCOCCUS CAROLINENSIS).

FIG. 2.—A BEAN MUTATION. ORIGINAL ON LEFT, MUTANT ON RIGHT. DARK BLUE GROUND COLOR SAME IN EACH. NO MOTTLING ON MUTANT.

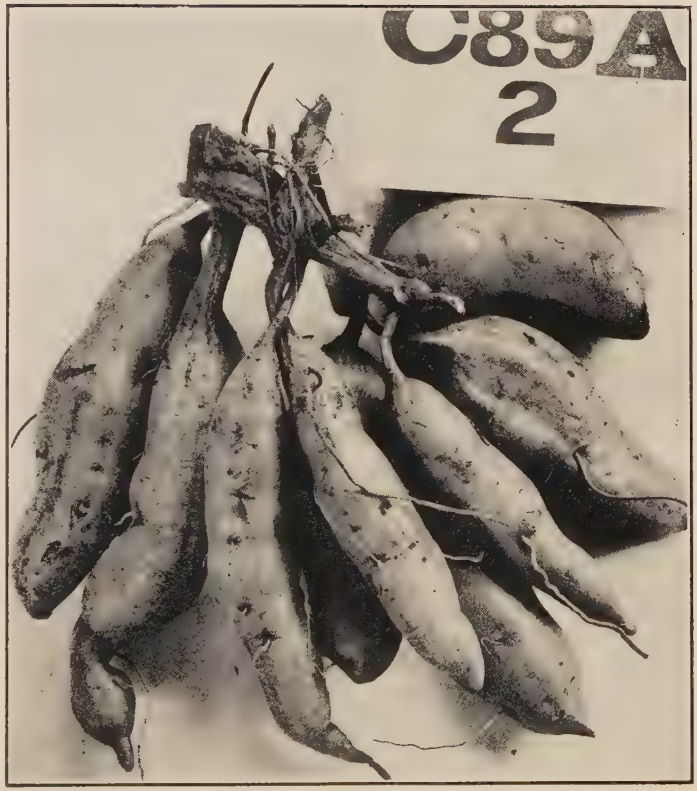


FIG. 1.—A PROMISING SWEET POTATO HYBRID (C89A).

FIG. 2.—HEAVY PRODUCING STRAIN OF PIGEON PEA.

politan population demands a yellow corn. For this reason, the local markets rarely handle any white corn. Because of this peculiar condition the agronomy division is preparing to meet the demands of the future market by hybridizing the Guam corn with some yellow varieties in order to ultimately develop a yellow variety which will possess the desirable characteristics of the Guam corn.

CASSAVA.

A fertilizer experiment on a small scale was carried on in field X at the station. Results are not yet available as the plants are only in their tenth month of growth.

Varietal tests with cassava are also being conducted in the same field, the object being to introduce superior varieties. The tests consist of five varieties, imported from the Philippine Islands through the courtesy of P. J. Wester, horticulturist for the Philippine government, and four varieties from the mainland, selected personally by F. G. Krauss of this station.

The importance of the cassava as a root crop is exemplified by the number of its cuttings, which were distributed in lots of from one to two dozen to individuals. The value of the cassava as a carbohydrate feed for hogs is recognized, the hog raisers of Hawaii frequently requesting from one to nine thousand cuttings of the best varieties.

BEANS.

Since 1917 garden beans of different varieties have played an important rôle in the make-up of small backyard gardens and military company gardens. In fact, the bean was found so important that much time and care was devoted to developing heavy producing strains of the several varieties suggested by the emergency food crop program. Selected beans in lots of from 1 ounce to 1 pound are generally allotted to each applicant to whom the recommendation is made to allow one-half of the crop to go to seed.

Mutation in beans.—A mutation was observed among the Early Refugee variety, No. 1167, a strain harvested after its third generation of growth from selected seeds. The sport of a single plant was discovered among the 200 individual plants when undergoing further selection in the laboratory. Forty-seven of the sport beans were planted. In each generation, and for three successive generations, they reproduced beans identical with the original mutant in physical appearance. Both the parent and the mutant beans showed the same peculiar dark purplish ground work color not possessed by any other lot of beans under test. The dissimilar characteristics between the parent and the mutant (see Pl. V. fig. 2) are summarized as follows:

Dissimilar characteristics observed in beans of parent and mutant plants.

	Nature of growth of plant.	Color of fresh pod.	Color of matured bean.	Length of bean.	Width of bean.
				Inch.	*Inch.*
Parent	Bush	Olive green	Dark purplish blue with light orange mottling.	$\frac{1}{2}$	$\frac{5}{16}$
Mutant	do	Wax yellow	Dark purplish blue	$\frac{17}{32}$	$\frac{9}{32}$

Mr. E. J. Mooklar, formerly of this station, tested the edible quality of the sport bean and pronounced it very succulent and tender, when cooked, and one of the best edible-pod beans.

SWEET POTATO BREEDING EXPERIMENTS.

Preliminary work with sweet-potato breeding was begun in December, 1917. The object of this project was to create some new varieties possessing, among other desirable characteristics, early maturity as the predominant feature. While the parents used for this purpose had both good and bad qualities, the work was begun with the hope that by hybridizing certain individuals the desired characteristics could be obtained from some of their seedlings. However, the seedlings produced from the same seed pod revealed the fact that most of the parents used were multiple hybrids. In many cases where three seeds from the same seed pod were planted, three seedlings, each having a distinct leaf pattern, arose. The results expected from such seedlings may not, therefore, be in accordance with the actual realization. The present work gives every indication of promising results. Seedling C89A has proved to be a very prolific individual, having purple and white mottled flesh (Pl. VI, fig. 1). Seedling C111A as an edible is one of the finest varieties of sweet potatoes, being nonfibrous and very mealy.

MISCELLANEOUS CROPS.

Field turnips.—Plantings of the seeds of the round field turnip (*Brassica rapa*), the sample of which was received from Canton, China, were made 18 inches apart in 24-inch rows in field N. When harvested after a growing period covering 18 weeks, the crop gave a calculated yield of 43.5 tons per acre. Individual roots measured 12 inches in diameter and 9 inches in length.

Pigeon peas.—Work on pigeon peas was confined to the growing of seeds selected from high seed-yielding strains (Pl. VI, fig. 2) for general distribution among the poultry raisers. The peas serve as a substitute for corn and other grains commonly marketed as poultry feed.

Dry-land taro.—At the first Territorial fair in 1918 the taro exhibit demonstrated the several ways of successfully growing taro by adapt-

ing the plant to climatic and soil conditions of the different localities in Hawaii. The dry-land varieties attracted considerable attention among the homesteaders and landowners whose lands are non-irrigated. This station has received many requests from interested parties for dry-land taro for propagation purposes, but owing to the limited supply only a very small quantity was furnished to each applicant.

CASTNER FORAGE-CROP STATION.

On account of the unusual drought which prevailed at the forage-crop station at Castner progress with some of the introduced forage crops was retarded. In 1918–19 a rainfall of only 30.32 inches, compared with 58.56 inches of the previous fiscal year, was responsible for considerable retardation in the growth of all grasses. As a result some of these grasses died, while others have had a hard time to exist.

ROOT CROPS.

Cassava.—An extensive fertilizer experiment was instituted at Castner during the fiscal year 1918. The cassava was planted April 2, 1918, and will be harvested in September, 1919.

That the drought had a deteriorating effect on the plants is proved by the very poor growth of the cassava. The branches are undersized and the leaves are proportionately small.

Edible canna.—The edible canna was found to be desirable either as a soiling crop or a crop for starch production. Once the plant gets the proper start it will grow without need of further attention.

At Castner 8 plats with hills spaced at 3 by 6 feet were planted to this crop and after 14 months' growth the following data were secured:

Results of experiments with edible canna at Castner.

No. of plat.	No. of hills.	Plat yield.		Calculated acre yield.		No. of plat.	No. of hills.	Plat yield.		Calculated acre yield.	
		Tubers.	Tops.	Tubers.	Tops.			Tubers.	Tops.	Tubers.	Tops.
		Pounds.	*Pounds.*	*Tons.*	*Tons.*			*Pounds.*	*Pounds.*	*Tons.*	*Tons.*
1	4	68.75	40	20.79	12.1	5	4	63	46	19.05	13.89
2	4	73.75	47	22.35	14.21	6	8	104	76.75	15.73	11.6
3	4	68	40	20.57	12.1	7	4	74	40	22.38	12.1
4	4	62	43	18.75	13	8	4	77	47	23.29	14.2

Despite the dry weather the edible canna made a remarkable growth. In the company gardens the plant attained a height of 10 feet where irrigated.

Field beets and field carrots.—Where irrigation can be made available, these two root crops bid fair to become the succulent feed for horses and cattle of the Wahiawa district. The Giant White carrot

and Long Red mangel produced roots weighing 6 and 12 pounds, respectively, after a period of 10 months' growth without irrigation.

Potatoes.—The hot and dry weather made the planting of potatoes at Castner impracticable. When attempts were made to plant the Hamakua Hybrid variety under the unusual weather conditions, it was found that the cut potatoes were dried by the intense heat before they had a chance to sprout.

On May 23, 1919, seed potatoes, certified in New York to be blight resistant, were received by the pathological division of this station and turned over to the agronomy division for trial planting. Samples were distributed to the military company gardens for cooperative tests. At the time of this report (June 30, 1919), no sign of blight is to be observed on any of the plants.

LEGUMES.

Annual white sweet clover.—This clover (*Melilotus alba annua*) was sent to this station by Prof. H. D. Hughes, of the Iowa Agricultural Experiment Station, Ames, Iowa. A portion of the seeds was planted at the forage-crop station, where the plants spread well, made vigorous growth, and showed good seed-producing characteristics. This sweet clover will be planted on a larger scale at the station in Honolulu in order to determine its value as a feed for cattle and horses.

Alfalfa.—The attempt to grow alfalfa without irrigation at Castner was unsuccessful. It would be apparently impracticable and decidedly unprofitable for a farmer to try to grow alfalfa on a large scale without the aid of irrigation even in Wahiawa, the farming district immediately adjoining the reservation. The alfalfa at the substation is making very little growth on account of the extreme drought.

GRASSES.

The grass plat experiments at Castner were also handicapped by the extreme drought. Certain of the grasses are evidently drought resistant, since they remain green, yet their growth is stunted and their palatable qualities affected.

Several species of grasses which were adapted to Florida conditions were sent by Mr. J. B. Thompson, of the Florida Agricultural Experiment Station, Gainesville, Fla., for trial planting at this station. Unfortunately the seeds failed to germinate.

The Merker grass (*Pennisetum merkeri*), another grass received from Mr. Thompson, is not only growing very luxuriantly, but is stooling heavily. In physical appearance it resembles the Napier grass (*Pennisetum purpureum*). Data on the yield are not available at this time.

RAINFALL.

The following tabulation gives the comparative rainfall readings in inches for the past two years at the substation at Castner:

Rainfall at Castner substation for the fiscal years 1918 and 1919.

Month.	Year.		Month.	Year.	
	1918–9	1917–8		1918–9	1917–8
	Inches.	*Inches.*		*Inches.*	*Inches.*
July	1.9	1.3	February	0.85	5.8
August	3.9	.96	March	2.4	3.6
September	7.4	5.8	April	.19	9.8
October	1.1	3.6	May	1.1	1.9
November	5.8	3.4	June	1.8	5.8
December	2.9	9.3			
January	.98	7.3	Total	30.32	58.56

DISTRIBUTION OF SEEDS AND CUTTINGS.

During the fiscal year the agronomy division distributed seeds and cuttings to the emergency war gardeners, dairymen, and to ranchers. For the 12 months ending June 30, 1919, seeds and cuttings were distributed to 425 applicants in amounts as follows:

Seeds and cuttings distributed during year ending June 30, 1919.

Crop.	Seeds.	Cuttings.	Crop.	Seeds.	Cuttings.
	Pounds.	*Number.*		*Pounds.*	*Number.*
Alfalfa	32		Sorghum	53	
Beans	107		Cassava		31,529
Corn	480		Uba cane		3,324
Grass seed and cuttings	1,056		Edible canna		5,058
Pigeon peas	72		Napier grass		1,412
Dry-land rice	25		Sweet potatoes		12,771

REPORT OF THE DIVISION OF PLANT PATHOLOGY.

By C. W. Carpenter.

The division of plant pathology during the fiscal year 1919 continued the program of work set forth in the 1918 report. The Territorial county agents and other extension agencies cooperated with the division, and the pathologist, thus greatly relieved from the burden of extension and demonstration work on insect and disease control, was enabled to devote considerable time to investigation and experimentation activities. With the close of the war it was again found practicable to give attention to important research problems in which immediate practical results were less certain. The manuscript of a bulletin entitled "Potato Diseases in Hawaii and Their Control"[13] was submitted early in the fiscal year for publication.

[13] Hawaii Sta. Bul. 45 (1920).

TARO ROT.

A preliminary study of the disease reveals the fact that there are several forms of taro rot present in Hawaii. The grayish to brownish rot of the taro corm (the edible underground portion variously called root, tuber, bulb, etc.) is by far the most common and destructive type in the field. The appearance of the affected taro varies considerably, sometimes being gray, soft, and mushy like poi, and at other times more dry and firm and grayish in color, or having merely a brownish discoloration of the tissues adjacent to the large root fibers which traverse the corm. Pathological culture studies of taro rot as it exists in the corm while still in the soil has resulted in the isolation of a predominant organism which resembles *Pythium debaryanum*. Since this latter organism is generally considered responsible for a number of other vegetable rot troubles in moist situations and under favoring conditions,[14] is a parasite of no mean capabilities, there is every indication that this species or a near relative is the cause of the common form of taro rot. It has been previously noted[15] that this organism was found associated with a root rot of rice in Hawaii. A preliminary inoculation experiment with the taro organism resulted in rot of the inoculated taro, while in no case did the uninoculated but otherwise similarly treated taro develop rot (Pl. VII, fig. 1). The taro, kept in moist chambers, sprouted vigorously during the time of rot development, a fact which would indicate continued vitality. Furthermore, that the development of the organism is accompanied by the formation of an enzym is evidenced by changes of the tissues several centimeters distant from the point of inoculation and beyond a point where the organism can be recovered. In the only experiment of this kind attention was directed to these deep and distantly affected tissues and an attempt made to isolate the uncontaminated parasite resulted in failure to obtain the organism.

The organism *Sclerotium rolfsii* was found associated with a rot which occurred in taro several days after it was pulled. Further investigation on the causes of taro rot will be carried on at the first favorable opportunity.

A circular letter on taro rot, furnishing available information to taro growers, was prepared by the pathologist.

Taro rot investigations on Molokai.—A survey of the valley of Halawa, island of Molokai, showed the taro growing there to be in a precarious condition, owing to the presence of a taro rot disease. The rot was of the type previously mentioned as associated with the organism *Pythium debaryanum*. It was thought that conditions would be improved by letting the taro lands rest awhile, or by the

[14] Hawkins, L. A., U. S. Dept. Agr., Jour. Agr. Research, 6 (1916), No. 17, pp. 627–639.
[15] Hawaii Sta. Rpt. 1918, p. 43.

practice of crop rotation. However, the suggestions of resting the patches, rotating with rice, or even plowing and harrowing after drying them out, met with little enthusiasm among the planters who make their land serve as the chief means of livelihood. As a result of continuous cultivation covering a long period, the soils have become very acid and otherwise unfavorable to the crop, but it is believed that this condition can be best corrected by plowing up, aerating, and resting the lands, or by planting them to other crops. Since there was no inclination to practice either method, applications of lime were recommended as a practicable way to ameliorate the existing conditions. A small demonstration experiment, carried on in cooperation with the trustees of the Bernice P. Bishop estate, was started on land of that estate in Halawa, in which tests with applications of lime, coral sand, and fertilizer were made. The selected land was a taro patch which, for several years, had grown very little marketable taro, most of which was more or less decayed when pulled up.

Mr. C. C. Conradt, of Pukoo, Molokai, consented to represent the experiment station in looking after the experiments in Halawa, in addition to acting as collaborator for this station on Molokai, where there is no regular county agent. Data on the results of the experiments are not yet available.

SPRAYING TO CONTROL THE BANANA FRECKLE DISEASE (PHOMA MUSÆ).

The banana freckle disease, described in the 1917 and 1918 reports of this division,[16] continued to do serious damage to the banana industry. As previously noted, this disease affects almost exclusively the Chinese or dwarf banana (*Musa cavendishii*). The disease spots the leaves and fruit; the former prematurely dry and fall, resulting in a general weakening of the plant; the latter appear blackened and disfigured, and unevenly ripen in small bunches.

The larger plantings at Mokuleia, where the bulk of the best fruit is grown, were so threatened by the disease that drastic methods were undertaken in a 100-acre plantation in an effort to check its progress. The pathologist is deeply indebted to Mr. A. J. Campbell, who not only made this cooperative project possible, but maintained throughout the work a keen personal interest and submitted valuable suggestions thereon. The campaign consisted of pruning the trees and burning the affected leaves, removing the upper portion of the stump when a bunch was cut to lessen the infection of the suckers, pulling out the worst affected and otherwise undesirable plants from about 25 acres, and planting cane therein. The more desirable younger fields were retained and sprayed with a fungicide. In the

[16] Hawaii Sta. Rpts. 1917, pp. 40, 41; 1918, pp. 36–39.

spraying work, attention was directed particularly to the upper surfaces of the leaves.

Preliminary experiments showed that Bordeaux mixture would not spread well on the waxy leaves, nor would the lime-sulphur spray. The addition of resin sal soda sticker to Bordeaux mixture, however, proved very satisfactory in overcoming the difficulty. The formula for Bordeaux applied generally in the work is that known as the 4:4:50 formula, though the 4:3:50 and the 5:5:50 formulas were applied to certain plats by way of experiment. The resin sal soda spreader sticker is prepared by boiling 1 pound of resin and one-half pound sal soda in 2 quarts of water until the proper degree of combination is effected. Subsequent experimentation with this formula and others showed that a more workable mixture resulted if the combination was as follows: 4 pounds resin, 2½ pounds sal soda, and 2 gallons of water. Two quarts of the sticker was used with each 50 gallons of Bordeaux.

The Bordeaux mixture was applied with a 100-gallon capacity sprayer, equipped with two lines of spray hose 200 feet long, in 50-foot sections, so that desirable combinations could be readily used, depending on the distance of the plants from the sprayer. (See Pl. VII, fig. 2.) Eight-foot extension rods and small-capacity side-outlet cyclone nozzles were found practicable. Since a relatively long time must be spent on each plant in order to reach the leaves at the proper angle, the small-capacity nozzles were found to give more satisfaction than the larger ones. Temporary roads were constructed wherever needed through the plantation, and portable bridges were made for crossing irrigation ditches, etc.

It was found to be impracticable to thoroughly prune out all infections with a crop like bananas, since plants of various ages were affected, the young suckers becoming infected from the old plants, etc. Too extensive cutting of leaves of plants was found harmful to the fruit, and when attempted on rather young plants, the pseudo-stem later developed such a constriction at the top that the bunch could not issue normally; assisting the bunch to emerge did not result in any material improvement. A similar effect resulted from the pruning brought about by the premature falling of the leaves. It was found, however, that a few leaves could safely be removed, though it was rather difficult and almost impossible to teach the Chinese laborers the discrimination necessary.

As a result of eight months' prosecution of the pruning and spraying campaign on this plantation, there is every indication that the method will be a successful one. The plants throughout are looking very much better than when the campaign started. Conclusions either as to the effectiveness or practicability of the method can not be determined definitely at this time.

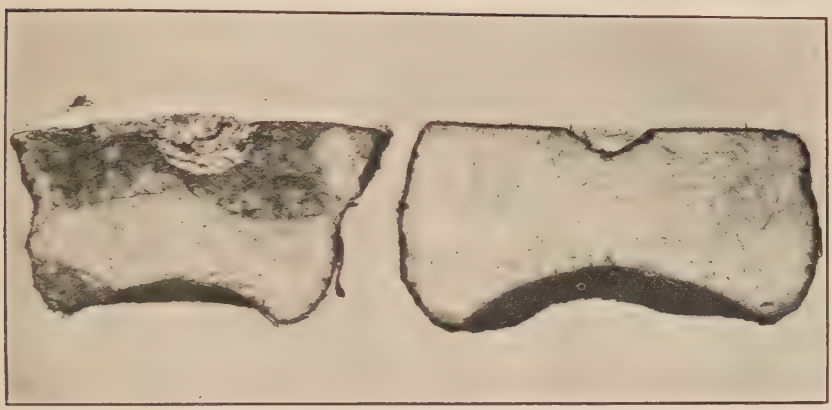


FIG. 1.—TARO ROT DISEASE DUE TO FUNGUS OF PYTHIUM DEBARYANUM TYPE. INOCULATED ON LEFT; CHECK ON RIGHT.

FIG. 2.—SPRAYING BANANAS FOR CONTROL OF FRECKLE DISEASE.

FIG. 1.—CONTROL OF MITE DISEASE OF PEPPERS. SPRAYED WITH LIME SULPHUR ON LEFT; NOT SPRAYED ON RIGHT.

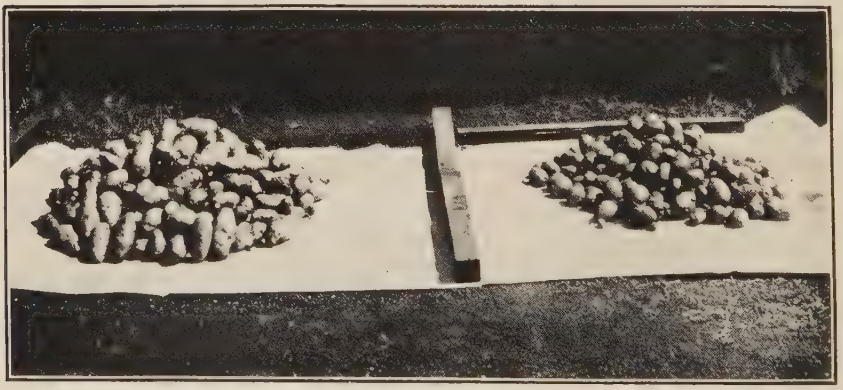


FIG. 2.—CONTROL OF MITE DISEASE OF POTATOES. SPRAYED WITH LIME SULPHUR ON LEFT; NOT SPRAYED ON RIGHT.

Recommendations to prevent the spread of this disease to other banana growing countries were made to the Territorial representative and inspector of the Federal Horticultural Board, and are being well carried out. Since the disease was observed on no island other than Oahu, suggestions were also made to the Territorial inspector to put into force certain restrictions regarding the transfer of banana suckers from Oahu to the other islands.

A MITE DISEASE AFFECTING SWEET PEPPERS.

A peculiar disease condition was noted on sweet peppers growing in dry and hot situations, and is characterized by the curling and stunting of the young leaves and buds. Though little attention has been focused on the disease, examination shows the symptoms to be practically the same as those previously noted[17] associated with mite infestation in the potato and tomato. Numerous mites are present, and the disease and its cause seem to be the same as that known as the potato mite disease. A small experiment carried on with diseased sweet peppers showed that applications of sulphur or lime-sulphur spray controlled the disease affecting them as well as that affecting potatoes. (See Pl. VIII, figs. 1 and 2.)

NEW ROOT-ROT PROJECT.

During the fiscal year the pathologist observed the presence of several very malignant diseases which call for immediate attention. As yet, however, their origin is more or less obscure, and while they have many conflicting symptoms and characters it is quite possible that some may prove quite identical in nature. Certain observations and work made to serve as a basis for a plausible working hypothesis were carried along the lines offering the most promise. This investigation, which is called the root-rot project, will include some studies on the microorganisms of Hawaiian soils.

MISCELLANEOUS NOTES ON PLANT DISEASES.

Among the microorganisms observed during the year and not noted in previous pathological reports are:

Sphærostilbe coccophila.—An entomogenous fungus, apparently parasitic on scale insects which infest the grapevines at Wahiawa, Oahu.

Sclerotium rolfsii.—A stem disease of peanut and affecting taro as storage rot.

Phytophthora colocasiæ.—Found in Oahu, Molokai, and Hawaii on taro leaves.

Cercospora bolleana. Known as the fig leaf spot, and observed in Oahu.

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[17] Phytopathology, 8 (1918), No. 6, pp. 286, 287.

Sphærotheca pannosa.—Rose mildew, found in Oahu.

Nematodes.—These organisms were found at Pearl City and Mokuleia, Oahu, associated with root rot accompanying the banana center leaf necrosis disease and chlorosis, noted in the 1917 report of this division[18]. In Oahu nematodes were also found associated with the root and crown rot of hibiscus.

REPORT OF THE POULTRY DIVISION.

By L. M. Ross.

During the past several years the major part of the poultry work of the station was conducted at the Glenwood substation, where, under Hawaiian conditions, single-combed White Leghorns were bred specially for egg production. During the past year, however, some attention was given to poultry investigations at the central station at Honolulu. This particular work was carried out with the following objects in view: (1) To ascertain the best system of feeding poultry in the Hawaiian Islands in order to obtain the highest practicable standards of egg production; (2) the development of methods for the most successful brooding and rearing of young poultry; (3) the development of the most effective methods for combating poultry diseases prevalent in Hawaii; and (4) the general encouragement and development of the poultry industry in Hawaii.

SOREHEAD OR CHICKEN POX.

The susceptibility of young chicks to the inroads of sorehead constituted in times past probably the most serious drawback to the successful production of chickens under Hawaiian conditions. Officials of the Territorial board of agriculture and forestry have to a considerable extent overcome this disease by their gratuitous distribution of the proper vaccine. It was found that prompt isolation of suspects, the careful attention to sanitary conditions, and one or two treatments with some suitable antiseptic to the heads of the quarantined birds resulted in reducing the damage from sorehead to negligible percentages. It is thought that unsanitary conditions are highly responsible for the development of conditions which are favorable for the spread of sorehead in poultry flocks. Foul and dirty quarters are probably the most important predisposing factors. In Hawaii certain poultry raisers pay special attention to the provision of sanitary quarters and yards for their flocks; and their young and adult stock have, as a consequence, been free from sorehead. It has been deemed advisable to procure from a breeder foundation stock which has not been subject to sorehead infection, so that this

[17] Hawaii Sta. Rpt. 1917, pp. 36–42.

stock may not be a carrier of the disease. Strict sanitation should be practiced in such small matters as drinking vessels, roosting quarters, nest boxes, etc., and the poultry should be frequently transferred to fresh runs; the used runs should be plowed, dug, or planted to a crop in order to clean the ground. Where sorehead reached an advanced stage, calcium sulphid was found helpful. One tablespoonful of the powder mixed into a moist mash for each 25 hens should be fed daily until cure is effected.

POULTRY CANKER.

This disease is a very common one in Hawaii. In the course of a preliminary experiment, it was found that the following procedure ordinarily gives relief unless the disease has reached a far advanced stage. The ulcer, and portions of the flesh surrounding it—both inside and outside the mouth—must be painted with tincture of iodin immediately after the canker has been firmly compressed from the outside of the mouth; this compression will greatly eliminate the suppurated matter which is then ejected through the nostrils. Arrangements should be made to have handy a small pan, or other vessel from 3 to 4 inches deep, filled with kerosene oil. Into this kerosene the beak and nostrils of the chickens should be dipped, the head being held there for a few seconds. This operation should be repeated at least three or four times, after which a 1-grain capsule of quinine should be administered to each fowl. If this method of procedure be followed three or four days in succession, the canker will disappear and the chickens will be cured.

COMMERCIAL ASPECTS OF THE POULTRY INDUSTRY.

At the present time the poultry industry in Hawaii is relatively in its infancy, nor is it felt that much increase in the production can be expected until the poultry possibilities are thoroughly demonstrated on a practical scale, and the various drawbacks which now beset the average poultry raiser are overcome. Available statistics show that during the year 1917 some 497,261 dozen eggs, valued at $186,691, were imported into Hawaii from California; during the same year 77,090 dozen, valued at $15,132, were imported from foreign countries, chiefly from China. These figures clearly show that Hawaii holds great possibilities for the disposition of the product of increased poultry flocks in the islands.

REPORT OF THE EXTENSION DIVISION.

By F. G. Krauss.

Hawaii produced more food and feed stuffs during that period in which the United States was at war than during any equal period in her history. The agricultural extension division rendered every assistance to the work of stimulating and increasing this production. Throughout the war period close and active cooperation was maintained with the Federal and Territorial Food Administrations. The station's available agricultural data and the demonstrations conducted by it were always at the disposal of the Territorial county agents. Cooperative contacts were maintained with the Territorial agencies at all essential points, a fact which it is thought proved an effective factor in contributing to the excellent results achieved by the islands throughout the war period.

During the months of December and January a trip was made to the mainland of the United States, the journey covering ground as widely separated as California to Massachusetts and Florida. The major object of the trip was to obtain data regarding the production and utilization of cassava, but it was also found possible to get in close touch with the extension activities under way in several of the representative States, and in the United States Department of Agriculture at Washington, D. C. Collections were made of the data descriptive of the most successful methods along extension lines with the idea of adapting them to the peculiar conditions present in the Hawaiian Islands.

EXTENSION SERVICE WORK.

It is felt that a real service was rendered by the division in acting as middleman between the producer of food crops and those sources of information which gave any promise of being helpful to the producer. During the last 15 years cumulative and rather valuable agricultural information was gleaned from the various agricultural institutions and activities of the islands by the superintendent of the extension division. This information was placed at the service of interested parties at the experiment station library, the extension service library, and elsewhere.

In a number of instances plans were prepared for planting and for crop rotation, and working drawings were made for the construction of locally made farm implements, and even for farm buildings and for silos.

The attempt was made to maintain at all times a supply of seed, cuttings, and tubers, etc., of all the improved varieties of crops the increased utilization of which was recommended by the extension division to the island farmers. During the year improved planting

stock sufficient for over 1,000 acres was distributed. A large portion of the 40 acres under cultivation was devoted to the production of improved strains of seeds and planting material. Germination and purity tests of seeds were made for those requesting them.

The extension division was also instrumental in arranging for the distribution of approximately 100 young registered Berkshire pigs; this distribution was made at prices which not only enabled the farmer of limited means to purchase the pigs, but also enabled him to secure a foundation stock of superior breeding.

Extended trips through the principal islands were made during the year. By this means close contact was maintained with the more important diversified agricultural projects. Lectures on timely agricultural topics, and demonstrations of spraying, budding and grafting, home curing of pork, and caponizing, were held whenever an opportunity presented itself. Numerous timely articles were prepared for the local press. These articles have always met with a generous and prompt response from the public, and seem a most effective way of reaching the public at large. A neighborhood reading service was in active operation throughout the year. The various agricultural journals received by the extension division were pooled with those subscribed to by others and the entire collection was placed where it could benefit all. Extra copies of agricultural bulletins, etc., which were received by the extension division, were likewise passed along to those interested.

COOPERATIVE EXTENSION ACTIVITIES.

Cooperative relationships were maintained with the other divisions of the Hawaii Experiment Station as well as with the various Territorial and private agricultural institutions. Extensive feeding tests were carried on in cooperation with one of the larger agricultural companies, and, in a number of places, cooperative experiments and demonstrations dealing with special crops or improved agricultural practices were inaugurated. The various local agencies responsible for the school-garden contests, home-garden work, etc., continued to receive the active support of the extension division, as did also the Maui pig club. The superintendent of extension served as one of the judges for the school and home garden contests, and as chairman of the pig-club committee. Likewise, he cooperated actively as a member of the committee of Maui County for the second Territorial fair in Honolulu, and was appointed chairman of the agricultural committee for the Maui County Fair to be held in the autumn of 1919.

The work done in connection with the collaborators constitutes an important phase of the cooperative activities of the division. The collaborator, who represents the division among the farmers of the

particular neighborhood in which he is located, ordinarily owns, or, at least manages, the farm on which he works, while the demonstrations conducted by him are usually incidental to his major agricultural operations. During a whole or a part of the year there were four collaborators on the island of Hawaii, two on Kaui, two on Maui, and one on Oahu.

In cooperation with the Territory of Hawaii, the extension division is operating a demonstration farm unit in the newly opened homestead tract on the slopes of Haleakala. The object of this farm is to demonstrate, in the shortest possible time, just what can be profitably produced under the somewhat peculiar conditions of soil, rainfall, elevation, and exposure to winds. The homesteaders rendered very valuable assistance in breaking up the land, while the adjoining ranch generously assisted in the matter of fence construction. The Territorial legislature appropriated money for a small set of buildings, the money to come from the loan fund when there shall be a sufficient balance in said fund to make the outlay practicable.

EXTENSION ACTIVITIES AT THE TERRITORIAL FAIR.

The second Territorial fair at Honolulu offered unusual opportunities for exhibits of the most promising agricultural developments which resulted as an outcome of the intense wartime agricultural activities. The division was largely instrumental in stimulating active and enthusiastic interest among the numerous exhibitors and it entered about 75 individual exhibits, which showed a wide range of products raised on the Haiku demonstration and experiment farm.

One of the principal features of the exhibit of the extension division was its collection of various home-grown feeds suitable for grinding and mixing. This feed was displayed not only to serve as well-balanced rations for every class of live stock, but each feed, in the mixtures designed, was also properly proportioned to suit the needs of the different animals. (See Pl. IX.) It was shown that for various classes of live stock it is practicable to produce and mix home-grown feeds which not only furnish a palatable balanced ration, but which also can be produced at approximately half the cost of equivalent imported feeds.

ENLARGEMENT OF EXTENSION ACTIVITIES ON THE ISLAND OF HAWAII.

Although four collaborators were maintained on the island of Hawaii in connection with the work of the Glenwood substation, it is realized that even a larger working force is required to cover the agricultural work of the largest island in the group. This need was manifested especially when the Territorial legislature withheld its

financial support from the county agent system which developed during the war. On April 1, 1919, R. A. Goff, who has for some years been in charge of the substation at Glenwood, was appointed extension agent for the island of Hawaii. He had previously acted in this capacity in cooperation with the Territorial food commission for the region adjacent to Glenwood, as well as collaborating in the extension work of the station.

J. E. Gamalielson, one of the collaborators on Hawaii, is an active poultry raiser and serves as secretary of the Glenwood Creamery Co., a cooperative organization of farmers who market their butter through this agency after supplying local demands. A summary of the creamery business for the last year by months is given below:

Summary of business of the Glenwood Creamery Co. for the year ended May 31, 1919. [a]

Month.	Amount of butter marketed.	Average price per pound.	Total returns.	Cost of marketing.	Month.	Amount of butter marketed.	Average price per pound.	Total returns.	Cost of marketing.
1918	*Pounds.*	*Cents.*			1919.	*Pounds.*	*Cents.*		
June	340	57	$193.68	$10.24	January	358	70	$245.28	$14.32
July	429	54.4	227.65	15.58	February	322	63.04	203.02	12.24
August	402	56	224.94	14.24	March	554	61.37	334.47	15.36
September	420	57	239.26	14.16	April	427	65	277.44	13.44
October	353	57	202.00	13.48	May	435	67	291.45	14.28
November	185	57.8	106.92	7.24					
December	219	70.73	154.89	8.56		4,445	61	2,720.00	[b] 151.44

[a] A summary for the preceding five years was given in Hawaii Sta. Rpt. 1918, p. 28.
[b] About 5½ per cent.

On the farm of Mr. Gamalielson, at Kaumana, Hilo, Hawaii, a flock of about 300 laying hens is maintained not only as a part of the regular business, but also as a demonstration of the possibility of a regular supply of eggs. The production of eggs, by months, is given below:

Egg production for the year ended May 31, 1919.

Month.	Number of eggs produced.	Month.	Number of eggs produced.
1918.		1919.	
June	2,496	January	1,404
July	2,754	February	4,389
August	3,536	March	5,182
September	4,491	April	4,301
October	4,440	May	4,129
November	3,280		
December	3,241	Total	46,743

From the above table it will be seen that there was an average production of 155.8 eggs per hen. The falling off in number of eggs produced in November and December was due to culling the flock.

NEEDS OF THE EXTENSION DIVISION.

Although the division has grown and flourished since its inauguration in 1914, it has many needs. A very apparent need is that of a well-trained marketing agent who not only would be able to attend to the various features of cooperative marketing organizations, but who would also stimulate active interest in farmers' organizations as a whole, as well as devote considerable time and attention to the further development of club work.

The islands also need the development of the farm bureau, which demonstrated its effectiveness throughout the mainland portion of the United States. A properly constituted farm bureau should be organized in every agricultural community throughout the islands, and should correspond in many ways to the chambers of commerce of up-to-date cities. Such an organization would greatly facilitate the work of the county agent, since it would bring him the counsel and advice of the more progressive farmers on the most pressing agricultural problems and their solution.

For the ultimate good of the islands, steps should be taken to increase such various organized projects as boys' and girls' pig clubs, potato clubs, corn clubs, etc. This class of work has heretofore been confined almost exclusively to school-garden work, and as a result of having received a great deal of attention from a number of different agencies throughout the islands, has been an unqualified success. It is felt, however, that the work should be made to embrace more than the production of vegetables; in fact, it should include the systematic raising of farm crops and animals as well. A promising boys' and girls' pig club was recently organized on the island of Maui.

Throughout the islands the ready responses to the home economics demonstrations occasionally made possible by various local agencies clearly proves the desirability of and the need for additional attention to this line of extension work. An efficient home demonstration agent visiting the more or less isolated homes of the island would impart a great deal of up-to-date information and, as an outside influence, serve to increase the happiness and efficiency characteristic of the average individual American home. Each county should have a county agent or full-time representative of the extension division.

HAIKU DEMONSTRATION AND EXPERIMENT FARM.

The Haiku demonstration and experiment farm was originally planned as a demonstration farm. However, a number of local problems developed which could be solved only by actual field and plat experiments. As a result, the experimental features of the work have developed in conjunction with those of the demonstration

activities until the two have acquired equal rank on the farm which serves as the base of operations for the extension division. Every theory of practice is first tried out on this farm before it is definitely recommended to the Hawaiian farmer. The practical nature of the demonstrations under way is evidenced by the increase in the number of visitors to the farm. Not only residents of the island of Maui, but also many people from all over the Territory were numbered among its interested visitors.

The experimental work consists in comparative variety tests of new and improved forage and food crops in order to determine their adaptability and possible advantages under local conditions. Cultivation and fertilizer experiments are designed to give definite information as to the best method to be followed for producing those crops which are found to be best adapted.

Another phase of the work is the growing of seed of these crops in order that the improved strains may be quickly disseminated throughout the island. The crops involved in the above work are as follows:

Crops grown at the Haiku demonstration and experiment farm.

Crops.	Number of varieties.	Crops.	Number of varieties.
Cowpeas	16	Grain sorghums	5
Culinary beans	4	Field corn	20
Pigeon peas	4	Popcorn	2
Peanuts	2	Sweet corn	2
Soy beans	12	Cassava	4
Velvet beans	2	Sweet potatoes	2
Alfalfa	10	Irish potatoes	8
Pasture grasses	2	Dry-land taro	20
Forage sugar cane	2	Japanese yam	2
Nonsaccharine sorghums	5	Edible canna	1

In addition to the above-mentioned work with crops, a number of experiments are under way to determine their utilization. The relative merits of the various crops under test are ascertained by feeding them to poultry, swine, dairy cows, and work animals belonging to the station. In addition to these experiments, milling and mixing tests of the various cured products of the farm are made with a view to establishing commercially practicable mixtures of Hawaiian-grown feeds as a substitute for imported feeds.

The hay crops are usually cured on portable curing trucks. The milling of cured hay and grains, including corn, Uba cane, sorghum, cowpeas, velvet beans, pigeon peas, peanuts, cassava, etc., and the mixing of the same to form balanced rations, constitutes one of the most practicable phases of the work and already has resulted in the local establishment of a large commercial milling plant for the manufacture of mixed feeds.

Variety tests, fertilizer experiments, and breeding work with corn.—The work with corn which was inaugurated in 1915, shortly after the establishment of the demonstration and experiment farm at Haiku, continued to broaden in its scope. In the breeding work another variety or strain of corn was developed to supplement the New Era 100-Day Yellow Dent. The new variety, which contains the same blood lines as the older type, possesses them in different proportions and requires a growing season of 20 days longer. This is a favorable feature for localities having ample rainfall.

When the writer was in Washington, D. C., during the past year, an experiment was arranged in cooperation with the office of Corn Investigations of the Bureau of Plant Industry, United States Department of Agriculture, to compare, by testing, a number of varieties of corn at different elevations with those already under test. The following mainland varieties are under test in direct comparison with the New Era 100-Day Yellow Dent and the local Kula type of corn: Mill Pond Prolific, S. P. I. No. 45903, U. S. Selection 119, Taxpan, No. 133, and Johnson's Prolific. These were planted at an elevation of about 500 feet at the Haiku demonstration and experiment farm, March 21–23, 1919. The corn, carried as No. 133, harvested June 25, was the only one having ears which matured during the fiscal year just closed.

The yield of No. 133, from a plat one-third acre in size, was at the rate of 40 bushels per acre, despite the fact that it was planted rather late in an unduly dry season. A second planting was made at the Haleakala demonstration farm at an elevation of about 2,000 feet, and a third planting was made at Waiakoa (Kula district) at an altitude of about 3,000 feet. These plantings are not yet sufficiently mature to justify any definite comparison.

In addition to the above-mentioned cooperative experiment, variety tests with the following varieties are being continued: Blount's Prolific, Casey's Purebred Old Virginia Shoe Peg, Virginia White Dent, Cocke's Prolific, Boone County White, Silver King, Improved Paymaster, Improved Southern White Snow Flake, Eureka, Bigg's Seven Eared, Hickory King, Wood's Gold Standard, Improved Golden Dent, Reid's Yellow Dent, Improved Leaming, Virginia Yellow Dent, Victory Yellow Dent, Virginia Ensilage, Pamunkey Ensilage, and Improved Yellow Creole. The writer selected the last-named variety in Louisiana during the winter of 1918–19.

The fertilizer tests have proved that it is absolutely essential to apply phosphate fertilizers in order to obtain a profitable yield of corn. The most economical results were obtained from those plats where a mixture consisting of equal parts of reverted and superphosphate had been applied at the rate of 500 pounds per acre.

Pigeon peas.—Probably the most important demonstration of the possibilities of a species relatively new to the islands as a field crop was that of the 15-acre field of pigeon peas first planted in March, 1917. Over a hundred other forage crops were tested, but the test with pigeon peas seemed to combine more good points with less unfavorable characteristics than any other crops which have been under observation. The fields were cropped from three to five times for seed and forage. (See Pl. X, figs. 1 and 2.) The product was cured as hay, which in turn was milled into meal and fed to all classes of live stock. As a result of this demonstration conducted by the station a neighboring rancher planted 350 acres. Part of this planting is now being harvested, milled in a well-equipped milling plant, and fed extensively to live stock on his ranch. It is estimated that probably 1,000 acres were planted in the Territory during the past two years, most plantings having been with seed bred especially by the Haiku demonstration and experiment farm for seed yield and other good qualities.

Alfalfa variety inoculation and fertilizer tests.—Previous to the year 1907, several unsuccessful attempts were made to establish stands of alfalfa. Even where the soil was well prepared, the young seedlings succumbed before attaining a height of more than 4 inches. Heavy manuring would have helped somewhat to overcome the difficulty, but owing to the limited quantity available this means of fertilizing was impracticable. In January, 1917, a combined variety test, inoculation, and fertilizer experiment was inaugurated with 4 strains of ordinary alfalfa, 2 strains of Peruvian, 2 strains of Grimm, 4 strains of Siberian, and 1 strain of an alfalfa received under the name of Liscomb. Plats that received the pure cultures (commercial) of tubercle organisms showed no appreciable improvement over the checks. One ton of hydrated lime per acre failed to show any benefit. Sulphate of potash, applied at the rate of 250 pounds per acre, gave no beneficial results. The plats which received a combined application of 100 pounds each of dried blood and nitrate of soda gave a very poor growth, little, if any, better than the check plats, and the plants finally died, as was the case with the checks. Stable manure when applied at the rate of 20 tons per acre resulted in a fair growth. The best results were obtained from the plats which received an application of 500 pounds of a mixture of equal parts of reverted phosphate and superphosphate. From the start the growth and development were excellent, a fact which indicates clearly that the only need of the soils in question was that of phosphate fertilizers.

The applications of phosphate fertilizers were repeated in January, 1918, and again in January, 1919. Notes on the relatives merits of the different strains and varieties were made in connection with plats

receiving applications of phosphate fertilizer. The alfalfas were seeded January 3, 1917, at the rate of 8 pounds of seed per acre in drills 18 inches apart. A mixture consisting of 500 pounds of equal parts of reverted and superphosphate was applied in the drills at the time of planting. The soil was raw guava upland from which one plant and two ratoon crops of pineapples had been harvested. This is one of the most unfavorable types of soil and its history has not been such as to warrant putting the soil in good condition. The varieties are arranged in the order of their apparent merit under the conditions, the best being placed first. The hairy type of the Peruvian alfalfa proved to be a vigorous upright grower, which recovered quickly after each cutting. The yield was 28 tons of green forage per annum from 12 cuttings. The smooth type of Peruvian alfalfa blooms from four to seven days later, and gives from 10 to 11 cuttings per annum, with a yield of green forage weighing about 25 tons. This variety, because of its smoothness, is usually more favorably regarded than the hairy type. The ordinary alfalfa was represented by four regional strains (Texas, California, Utah, and Idaho). These all did well under trial. Their leafage is more dense and in habit they are more spreading than the Peruvian type. They mature later, also. An average of eight cuttings, aggregating 20 tons of green forage per annum, was obtained. The variety received under the name of Liscomb did not differ materially from the common alfalfa. The two strains of Grimm alfalfa proved to be slow growing, somewhat stunted in habit, with small dense foliage. The yield was about 10 tons of green forage per annum. Under ordinary conditions in the islands this variety can not be recommended for hay; however, it may prove valuable for pasturage, especially under somewhat unfavorable conditions at the higher altitudes.

The Siberian alfalfas (Cossack, Orenburg, Cherno, and Semipalatinsk) were placed under test. While they are of too spreading a growth to be well adapted for hay-producing purposes they may prove valuable as pasturage where grown under unfavorable conditions of soil and moisture, as at the higher elevations where any palatable legume that will survive is to be favorably regarded. In the variety tests the yield ranged from 10 tons of green forage for the Cossack strain to less than 5 tons for the Semipalatinsk. The Turkestan variety made a poor showing and its culture is not recommended.

Experiments with potatoes.—This year marks the close of a four-year field experiment with potatoes. This experiment included comparative tests of numerous varieties, together with fertilizer and cultural experiments. The ordinary Kula (Maui) potatoes were formerly noted for their fine quality and fairly abundant supply in the Honolulu market. During recent years, however, both the quality and quantity have decreased to a marked degree. With a view to

EXHIBIT OF PRODUCTS GROWN IN COOPERATION WITH THE STATION, SHOWING THE POSSIBILITIES OF THE DEVELOPMENT OF A 40-ACRE UNIT IN 5 YEARS. CORN, PINEAPPLES, PIGEON PEAS, TARO, SUGAR CANE, AND HOME-GROWN MIXED FEEDS FOR LIVE STOCK.

FIG. 1.—PIGEON PEAS INTERCROPPED WITH CORN. PEAS CONTINUE TO OCCUPY LAND FOR 3 TO 5 YEARS.

FIG. 2.—HARVESTING AND CURING PIGEON PEAS ON HAY-CURING RACKS. PINEAPPLES IN FOREGROUND ROTATED WITH PIGEON PEAS.

rehabilitating the growing of this important food crop, restoring it to its former status, and, if possible increasing its importance, there was instituted in 1915 a rather comprehensive series of potato experiments. It was clearly shown that the best tilth possible should be provided on rather heavy soils. In order to maintain a fairly mellow condition of the soil throughout the growing season it was found necessary to incorporate in the soil a liberal amount of organic matter. The most practicable method of doing this proved to be that of turning under one or two good crops of velvet beans or cowpeas. About 25 tons of green matter per acre, when turned under, will ordinarily suffice to supply the requisite amount of organic matter in the soil.

It has been found from experience covering four successive seasons' plantings that to secure profitable yields it is essential to supplement the green manure with a liberal application of commercial fertilizer. A comparative test of the standard chemical fertilizers available in Hawaii showed conclusively that the phosphatic fertilizers are the controlling factor in maintaining a high degree of soil fertility. It was also found that potatoes respond to such fertilizers as readily as do corn, alfalfa, and other crops which, without the application of phosphate in some form, are practically failures. An application of 500 pounds of either superphosphate or reverted phosphate, placed in the hills at the time of planting, gave an increased yield of from 150 to 400 per cent over the untreated plats. Finely gound bone meal also gave satisfactory results.

In planting potatoes the best results were obtained where 2-ounce seed pieces, bearing at least two eyes, were used, the planting being made when the newly sprouted shoots were about one-quarter of an inch long. The potatoes were placed to sprout in single layers in subdued light where they were kept fairly cool by suitably controlled ventilation. Before planting, the seed was treated for scab, the whole tubers being immersed in a solution of formaldehyde, 1 pint to 30 gallons of water. It was also found that 4 ounces of corrosive sublimate to 30 gallons of water made an efficient dip. The seed was planted at 18-inch intervals in rows 30 inches apart, thus giving 11,616 hills per acre. About 1,500 pounds of seed per acre was used. In moderately dry seasons, plantings were made at from 4 to 5 inches in depth, but in moist seasons the seed was planted from 2½ to 3 inches deep.

One of the most critical problems in connection with the production of potatoes was that of eradicating the so-called blight and attacks from the recently noted mite and aphis. While these were responsible for considerable losses, methods have since been developed for safeguarding the crop by the use of Bordeaux-lime-sulphur spray

and nicotin preparations in adequate amounts. Such treatments add invariably to the cost of production, yet their very efficient results justify their use.

It is concluded that a lack of care in protecting the island's newly dug potatoes from sunshine is directly responsible for their poor keeping qualities. It is important that potatoes be placed in a cool dark storage as soon as they are dug. One of the varieties, when subjected to this treatment, kept in perfect condition for eight months. During the past two years the planting stock was grown from hill selected seed. The station's highest yielding variety gave an average yield of 1½ pounds per hill, but numerous hills yielded as high as 5 pounds of potatoes. It is regarded as fully established that carefully selected seed from individual hills will produce larger and more uniform crops than the general run of stock. The extension division has on hand a stock of selected seed potatoes of the New Era strain of Earliest of All, Producer, Snow, and White Rose. These are available for distribution to those planters who desire to test them, report on the results of the test, and, upon finding the varieties a superior kind, produce them in their own localities. The results of the potato variety test are shown in the table given below. No variety is included which for at least three seasons was not grown under field conditions. The range of yield in a variety during the different seasons has been as high as 40 per cent. The New Era Earliest of All yielded at the rate of 300 bushels to the acre, although the average yield was approximately 170 bushels per acre. During recent years yields as high as 170 bushels per acre under local conditions were very exceptional, even in the potato-growing districts of the island of Maui. In the Burbank varieties the low average yield was due to their late maturity and consequent susceptibility to blight and mites. These, on several occasions, have cut the crop short when otherwise an excellent yield would presumably have been obtained.

Results of potato variety tests at Haiku demonstration and experiment farm, showing approximate average yields, in pounds per acre, based on three or more crops.

Relative rank of variety.	Variety tested.	Approximate average yield per acre.	Relative rank of variety.	Variety tested.	Approximate average yield per acre.
		Pounds.			*Pounds.*
1	Earliest of All	10,200	13	Early Prizetaker	6,400
2	Producer	9,600	14	Gold Coin	6,200
3	Snow	8,350	15	Kula White	6,150
4	White Rose	8,100	16	Kula Flat	6,050
5	Bliss Triumph	7,700	17	Scotch Rose	6,000
6	Early Rose	7,600	18	Burbank, low top	5,950
7	Early Sunrise	7,400	19	Burbank, high top	5,400
8	Early Freeman	7,350	20	Burbank, Kula seed	4,650
9	American Wonder	7,250	21	Hamakua Hybrid (Kula, Kim strain).	4,000
10	Green Mountain	7,000			
11	Pride of Multnomah	6,500	22	Hamakua Hybrid (Yamata strain)	3,800
12	Netted Gem	6,450	23	Hamakua Hybrid (New Era strain	3,250

The division, basing its work on the results obtained in this variety test, is now using only the first five varieties listed, with the single exception of a select strain of low-top Burbank, which is to receive further trial. The earlier varieties, which usually escape the blight and mites, do decidedly better than the later-maturing sorts. After three years' effort, the selection work carried on to establish a variety immune to the blight has resulted in failure. It is thought that the best practice now available on Maui is that of growing early varieties best suited to the conditions and spraying them several times during the latter half of the growing season. These suggestions are made with special reference to the island of Maui, because there the conditions materially differ from those obtaining elsewhere in the Hawaiian Islands.

The cost per acre of growing a 100-bag (167 bushels) crop of potatoes at the Haiku demonstration and experiment farm was approximately $150. This includes rental of land, expense for tillage, seed, planting, harvesting, storage, etc. The crop, at present prices of $3.50 per 100 pounds, however, will be a profitable one if the yields produced by these best varieties can be maintained. When the yields fall to 50 bags (83 bushels) per acre, which is more than the average yield in the potato-growing districts of Maui, the profits are very small, although the cost of production is less there than in the Haiku section. A series of cooperative experiments in potato culture, the object of which is to demonstrate the most profitable methods of increasing the potato yield in those districts, is also in progress in the Makawao and Kula districts of Maui.

Pineapple experiments.—The pineapple experiments cover a tract of 10 acres; the first crop of this fruit was harvested at the close of the fiscal year. The experimental data, which require that each fruit be weighed as picked, necessitate as many as 2,500 individual weighings in the course of a single day's operations.

Tests with starch-yielding plants. A considerable number of trial plantings were made with plants which, it is hoped, will ultimately become sources of commercial starch. These plantings included edible canna (*Canna edulis*), and several varieties of cassava, sweet potatoes, and taro. The observations, made in connection with a trip to the mainland during the year just closed, indicate the possibility of commercial production of starch on a large scale. Such an industry, once established in the islands, would constitute another of the diversified industries; and the residual product of these plants, after their starch had been extracted, would become an important source of economic carbohydrate stock feed.

REPORT OF THE GLENWOOD SUBSTATION.

By R. A. Goff.

The economical growing of food and feed crops continued to be the principal object of work done at the Glenwood substation during the past year. Purebred single-comb White Leghorn poultry was kept and eggs for hatching purposes were distributed throughout the island. While experiments with a number of promising crops were carried on, the work was mainly centered on potatoes, beans, cabbages, corn, and alfalfa. Unfavorable climatic conditions make it very difficult to produce many of those crops which are easily grown in other parts of the Territory. It was conclusively demonstrated that these five crops can be successfully grown in this district, and, in order to increase their yields, this station has tried to find better cultural methods.

The superintendent devoted much of his time to visiting homesteads and plantations in the Kau, Puna, Hilo, and Hamakua districts, assisting the farmer in every possible way by the distribution of seed and by imparting information, and in establishing fields of alfalfa.

The Glenwood substation, which was conducted principally with Territorial funds, received during the past year some assistance from the Federal Experiment Station in Honolulu, which paid the wages of two of its laborers.

IRISH POTATOES.

Three varieties of potatoes were planted, the Hamakua Hybrid (both red and white strains), the Portuguese Red, and Pride of Multnomah (an Oregon seed potato). The Multnomah, which consistently and repeatedly proved to be nonresistant to blight, has, therefore, been a failure in this district, where spraying is prevented by rains. The Hamakua Hybrid and Portuguese Red have made good yields. Marketable potatoes in yields of from 90 to 120 bags are usually obtained, and since they sell at from $2.35 to $3 per bag a good profit is usually realized from them. During extremely wet and cold years only one crop can be grown and the yields are lower, but in 1917 and in 1919 potatoes yielded well in this district.

In somewhat limited fertilizer tests with the Hamakua Hybrid, in which superphosphate and nitrate of soda, applied singly and in combination in varying amounts, and stable manure were compared, it was found that the use of equal amounts (250 pounds each per acre) of superphosphate and nitrate of soda was most economical.

SWEET POTATOES.

Twelve varieties of sweet potatoes, which were found growing in the Hilo and Puna districts, were planted. Of these five died and six grew slowly; the Laupuuwai, however, which made rapid growth and as yet has not been attacked by the leaf miner, is thought to be an excellent variety for this locality. The Madeira and New Era varieties produced well, but required over a year in which to mature.

MAUI RED BEANS.

The table below shows the results of a fertilizer experiment on eight plats, each 675 square feet, planted to Maui Red beans:

Results of fertilizer experiment with Maui Red beans

Plat No.	Fertilizer applied per acre.	Yield per acre.	Plat No.	Fertilizer applied per acre.	Yield per acre.
		Pounds.			*Pounds.*
1	Superphosphate, 500 pounds in 2 equal applications	1,400	4	Superphosphate, 250 pounds	1,195
2	Check, no fertilizer	780	5	Stable manure, 20 tons	1,800
3	Superphosphate, 500 pounds in 2 equal applications	1,235	6	....do	1,975
			7	Check, no fertilizer	930
			8	Stable manure, 30 tons	2,030

It will be observed that stable manure gave the highest yields, but where a sufficient quantity can not be had for field planting, good yields may be obtained from the use of superphosphate alone.

DRY-LAND TARO.

Three varieties of taro, the Kuoho, Olaaoloa, and the Ala, were planted in February, 1919, and are doing better than any previously planted. The keiki, or sucker plants, are forming, and the crops should be ready to harvest by January, 1920. This is a somewhat longer growing season than is necessary at lower elevations, but a number of local growers have begun to plant taro where potatoes and cabbages do not thrive.

LICORICE ROOTS.

Roots planted in May, 1918, were a failure, since, after making a growth of three months, they died.

IMPROVED POHAS.

Records have been kept of the yields from the two plats of pohas which were planted in May, 1918. One plat contained the poha found growing wild in the woods; the other was planted to an improved giant variety obtained from Philadelphia. The native poha is perennial, and the pickings may be extended throughout the year.

The improved variety bears for a short season then dies. The native poha yielded 8 tons to the acre and the improved poha yielded 2½ tons to the acre. The improved variety is a much larger fruit, and, while only 40 pounds of the native poha can be picked and prepared for market in a day, over 200 pounds of the improved variety can be easily prepared. Both varieties make excellent jam. Where cultivation of the improved variety is unnecessary this fruit should become a paying crop.

ALFALFA.

In the substation plats alfalfa yielded from 20 to 30 tons of green feed to the acre and can be cut 9 times a year. The fields are still developing and should, after another year, produce even better yields. At lower elevations in the north Hilo district, fields, planted under the supervision of the superintendent and cut 11 times in 12 months, are growing stronger after each cutting. Various methods of planting were tried, but the one found most suitable to local conditions of climate and weed growth is that of drilling the seeds in rows 2 feet apart. After 6 months' time the plants usually cover the ground and check weed growth, so that rather infrequent cultivation is required. When growing alfalfa it is very essential to have the fields in which it is to be planted as nearly weed-free as possible. The substation is keeping track of the costs of planting and bringing the crop to the first cutting stage, but as yet these data are not complete. Cooperative experiments in the planting of alfalfa were started in 12 localities on the east side of this island and so far are promising.

SWEET CLOVER.

Sweet clover is a slow-growing plant in this district, is not seriously attacked by insects, and produces nearly as well as alfalfa. It is an excellent feed for dairy cattle, grows on soils too poor for other legumes, and when turned under enriches the soil.

CORN.

Three varieties of corn, Waimea White, Guam, and Cuban Red, have given good yields, the Waimea White doing the best of the three. In the Glenwood district stable manure is a splendid fertilizer for fields planted to corn, and phosphate fertilizer gives almost as good results. In a comparative fertilizer test with Waimea White, stable manure gave a yield of 2,600 pounds of corn to the acre; phosphate, applied just before planting, at the rate of 400 pounds to the acre, gave a yield of 2,415 pounds of corn. Nitrate of soda and complete fertilizers, which are more expensive than phosphate, gave lower yields and can not be recommended. The average yield per acre of the three varieties was as follows: Waimea White, 2,415 pounds;

Guam, 1,650 pounds; and Cuban Red, 1,200 pounds. Guam corn doubtless would do as well as or even better than Waimea White at lower elevations, and Cuban Red, which has the advantage of being hardier and more resistant to pests, can be grown where other varieties do not give good yields.

SORGHUM.

Texas Blue Ribbon, Early Amber sugar cane, kafir, Egyptian wheat, and feterita were planted in order that a green feed for dairy cows might be secured. It was known that these would ratoon and in this way eliminate the necessity of replanting after each crop. Because of heavy rains it is often difficult to plant corn in the proper season, and if the sorghums can be made to ratoon well, they will prove of inestimable value to local dairymen. In Hawaii all of these varieties mature seed which probably would become a source of poultry feed were some method to be found which would prevent birds from eating the maturing grain. The crop, secured from planting seed, averaged 22 tons of green feed to the acre, but the ratoon crops so far have been stunted and have not been used for fodder because of the possibility of their poisoning the cattle. As the sorghums continue to ratoon after each cutting, different fertilizers are being applied in an effort to secure a quick-growing, heavy second growth.

EDIBLE CANNA.

The edible canna which was introduced as a substitute for potatoes is now more largely used as a hog feed. At this elevation it produced 7 tons of roots to the acre with a nine months' growing season, but matures more quickly at lower levels. When well fertilized, the tops grow to a height of 8 or 9 feet; these tops, after being cut in 6-inch lengths, are fed by local growers to hogs. The roots as well as the tops are relished and furnish a large part of the ration; the latter, when mixed with 2 pounds of soured rice bran, cause the hogs to steadily increase in weight. Small fields of canna are kept growing at the substation and cuttings are distributed among homesteaders.

CASSAVA.

Cassava, from which tapioca is made, makes a rapid growth in the Puna district of this island. Cuttings were secured from that place and planted at the substation in the late autumn of 1917. It failed, however, to reach the size of plants 5 months old at the lower elevation. Waialua White and Trinidad varieties were also planted and are maturing slowly. A very good grade of edible starch can be made by grating the roots, and, after mixing them with water, straining them through cheesecloth. The value of these roots as a hog feed

is being recognized by many growers to whom cuttings were distributed.

PIGEON PEAS.

Pigeon-pea bushes grow to a height of 5 and 6 feet in the substation plats, and, although they do not mature seed, their younger branches, when cut off and ground, furnish a palatable feed for dairy cows. Since they are legumes, they have the added advantage of enriching the soil, especially when turned under as a green manure crop. Seed which was distributed to farmers in the vicinity of Hilo has developed into plants which are now bearing seed. The pigeon-pea crop is highly prized by those who have raised it.

GRASSES.

Demonstration plats of Kentucky blue, awnless brome, redtop, timothy, orchard, crested dogstail, Italian rye, and meadow fescue grass, planted in 1917, continued to grow well throughout the year. Originally planted in rows 3 feet apart, the redtop and Kentucky blue grass have spread until they now cover the ground and form a heavy mat; this feature makes the grasses valuable additions to the pastures of this district. Less than an acre of *Paspalum dilatatum*, or Australian water-grass, which was planted in 1916 from roots set in 2½-foot rows, furnishes all of the grazing needed for one dairy animal, since it has spread until the ground is almost entirely covered. Six acres of the native or wild grass is necessary to supply grazing land for one animal, so that Paspalum is easily worth five or six times as much as the grass found in the majority of local pastures. This station secured seed of these grasses for local dairymen who desired to improve their pastures. Twelve varieties of grasses and leguminous plants from Florida were planted in the field and in flat boxes, but failed to germinate.

POULTRY.

Purebred single-comb White Leghorn poultry has been kept, and eggs for hatching were distributed throughout the island at a nominal price. The entire flock netted a return of 26 cents per bird per month above cost of feed. At the same time, the flock supplied the hatching eggs used at the station and paid for the feed used by over 300 growing chicks. The hens of the entire flock average 12 eggs per month. The feed cost of each hen is 30 cents per month; the return above feed cost, when the eggs are sold on the market, is over 40 cents per bird. It has cost the station 85 cents on the average to bring a pullet to the age of 3 months, exclusive of the labor required, and about $2 to care for it until the time of laying. Poultry raising should become profitable in the Territory where small flocks are kept as a side line or in larger flocks of about 500.

COOPERATIVE EXPERIMENTS.

After demonstrating in experiment plats that phosphate fertilizers as well as complete fertilizers return large yields of potatoes per acre, arrangements were made with a Glenwood farmer to carry on a cooperative fertilizer experiment on his land. An acre was divided into eight equal plats to one of which a complete fertilizer was applied by the farmer at his usual rate of application. Another plat was reserved as a check plat where no fertilizer was applied; and in the other six, reverted and superphosphate were applied by the substation at the rate of 250, 500, and 1,000 pounds per acre. A second application of 150 pounds per acre was given to the plats which had received 250 pounds. The potato rows were about 40 inches apart and the fertilizer was applied in the rows and not scattered broadcast. At harvest time it was found that all the fertilized plats returned a 30 per cent larger yield than the check, and that the plats in which 400 pounds of phosphate had been used gave as large yields as the one in which the more expensive complete fertilizer had been used. Practically all of the potatoes planted in Glenwood this year have been fertilized with phosphate at a considerable saving to the planters as a result of the experiment, and all indications point to a larger yield than in previous years. The superintendent has ordered all the phosphate for the local growers, and will continue to do so until satisfactory arrangement for their purchase can be made with local dealers. On various farms demonstrations were also made of the use of poisons for cutworms, cabbage worms, potato blight, and sweet-potato leaf miner. Assistance was given to homesteaders in the purchase of reliable seed and poison for the various pests.

SCHOOL-GARDEN CONTESTS.

The superintendent acted as judge in the Star-Bulletin school-garden contest in the districts of Puna and Kau and in the final judging in the Kona district. He also served as judge in the Hilo Board of Trade home-garden contest.

BOYS' WORKING RESERVE.

The superintendent for four months acted as county director of the Boys' Working Reserve work on this island and for nine months had charge of the work on the east side. A trip was made around the island of Hawaii with G. A. Young, the executive secretary of the reserve in the Territory; a motion-picture machine was used to give exhibitions, and in each of the districts a practical talk was given.

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